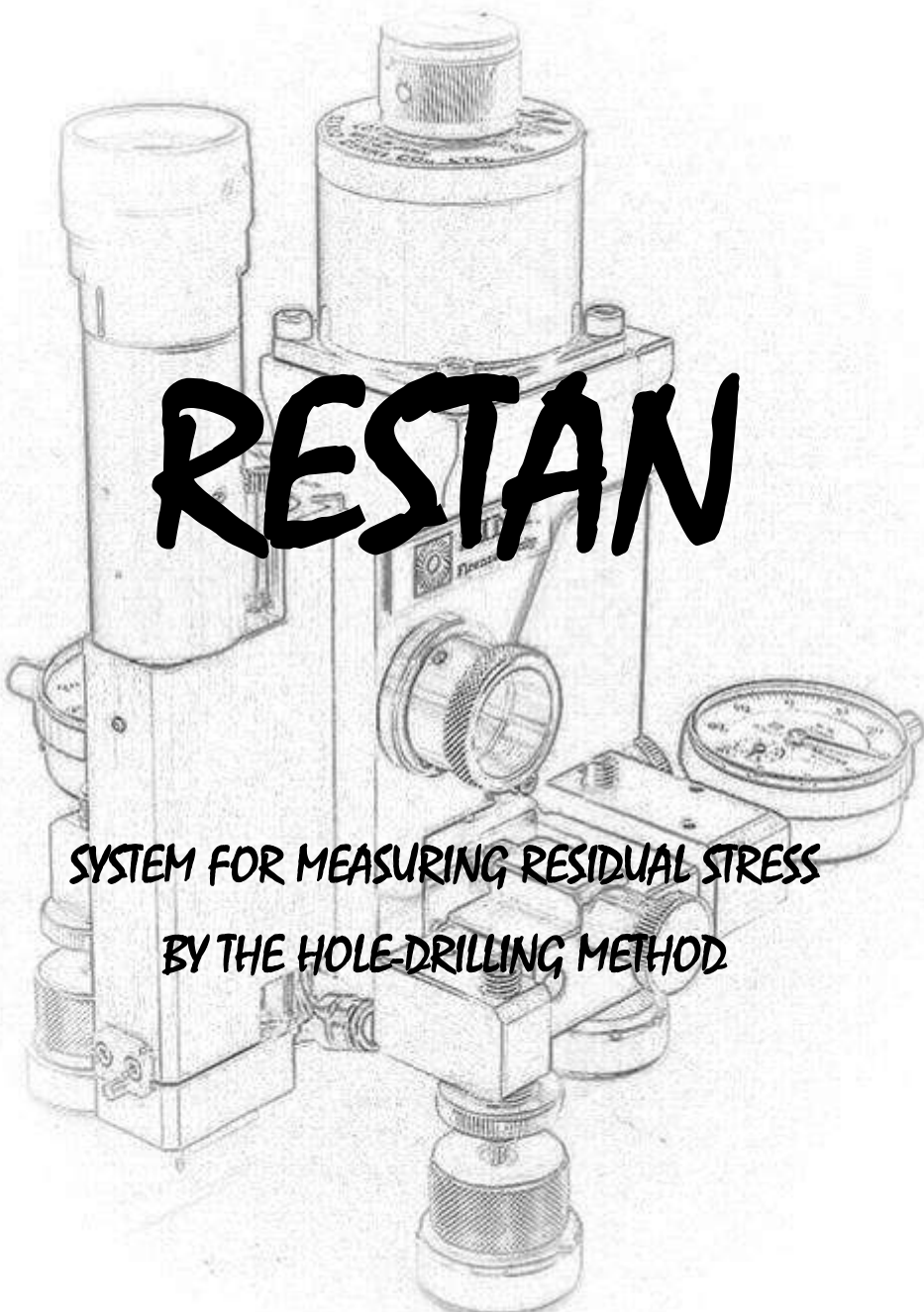




RESTAN

SYSTEM FOR MEASURING RESIDUAL STRESS
BY THE HOLE-DRILLING METHOD

RSM SOFTWARE OPERATING AND MAINTENANCE MANUAL

MANUAL ORIGINAL

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Italy

**WARNING:**

Read this Operating and Maintenance Manual carefully before starting to use the equipment.

Always keep this manual with the equipment.

Should you have any doubts or problems, contact the SINT Technology technical support team (support@sinttechnology.com)

1. INTRODUCTION

1.1. *Presentation of the system*

Congratulations for your choice. The system you have purchased is actually a development of the hole-drilling method that allows residual stress to be evaluated by measuring the relieved strains of a material after drilling a blind hole.

This system simplifies, automates and heightens the precision of all the operations involved in applying the hole-drilling method which had to be performed by an operator. Automation of the testing process has led to speeding up these operations, saving the operator from having to do the actual hole drilling and allowing him to concentrate on a limited number of operations that are necessary to achieve more accurate, repeatable results.

The main operations are the following:

- Centering of the drilling axes over the target of the strain gauge rosette
- Identification of the surface of the material and visualization of hole depth at each drilling step
- Hole drilling to specified increments and measurement of relieved strains
- Measurement of hole diameter and eccentricity.

Automation and simplification of these operations offer major advantages, the most important of which is that a large number of strain readings can be taken with great precision over the whole depth of a hole. This is indispensable for measuring the variation of residual stress with depth. Consequently, in addition to the calculation routines specified by standard **ASTM E837-13**, optimized procedures for processing test data that can determine residual stress with depth variations are included in the system's calculation software.

Another innovative feature is the overhung architecture of the system, which can be used on components or structures where access is difficult.

The system can be used with digital strain gauge amplifiers or analog amplifiers.

1.2. Description of the system

The basic system comprises:

- Positioning and drilling equipment (Mechanical-Optical Device)
- Control system (Electronic Control System)
- CD containing the control software (**RSM 6**) and data processing/analysis software (**EVAL 6**)
- Accessories:
 - N° 2 Analogic dial gauges
 - N° 1 Steel L-square
 - N° 1 Air turbine (**1-SINTT**)
 - N° 1 Set of 5 spare chucks for air turbine (**1-SINTC**)
 - N° 1 Special drill for centering (**1-SINTCTC**)
 - N° 2 Set of 5 tungsten carbide end mills, TiAlN coated, inverted cone-shaped, 1.6 mm diameter (**1-SINTCTT/1**)
 - N°1 Set of 3 allen wrenches (1.5 mm, 2 mm, 1/20") and a special key (1/20")
 - N°1 Special open-end wrench (**U-Key**)
 - N°1 Screwdriver
 - N°1 Compressed air unit (assembled) consisting of: on-off valve, pressure control with pressure gauge, 5 µm filter, 0,01 µm air filter and 0,1 mg/m³ residual water/oil filter, 1 male-to-male connector, 2 female-to-fast connection connectors
 - N°2 Lengths of flexible pneumatic pipe, 6 mm OD - 4 mm ID, 1 m and 2 m long
 - N°1 Pneumatic pipe with fast-to-fast connector, 150 mm long
 - N°1 Torch
 - N°1 RS-232 cable
 - N°1 RS-232 / USB adapter
 - N°1 BNC cable /alligator clips for the zero-setting procedure
 - N°1 Shielded cable for stepping motor control
 - N°1 Power cable for the electronic control system
 - N°1 Software security key USB
- Carrier case
- Operating and maintenance manual and certificates.

A standard configuration of the system is shown in Fig. 1.1.

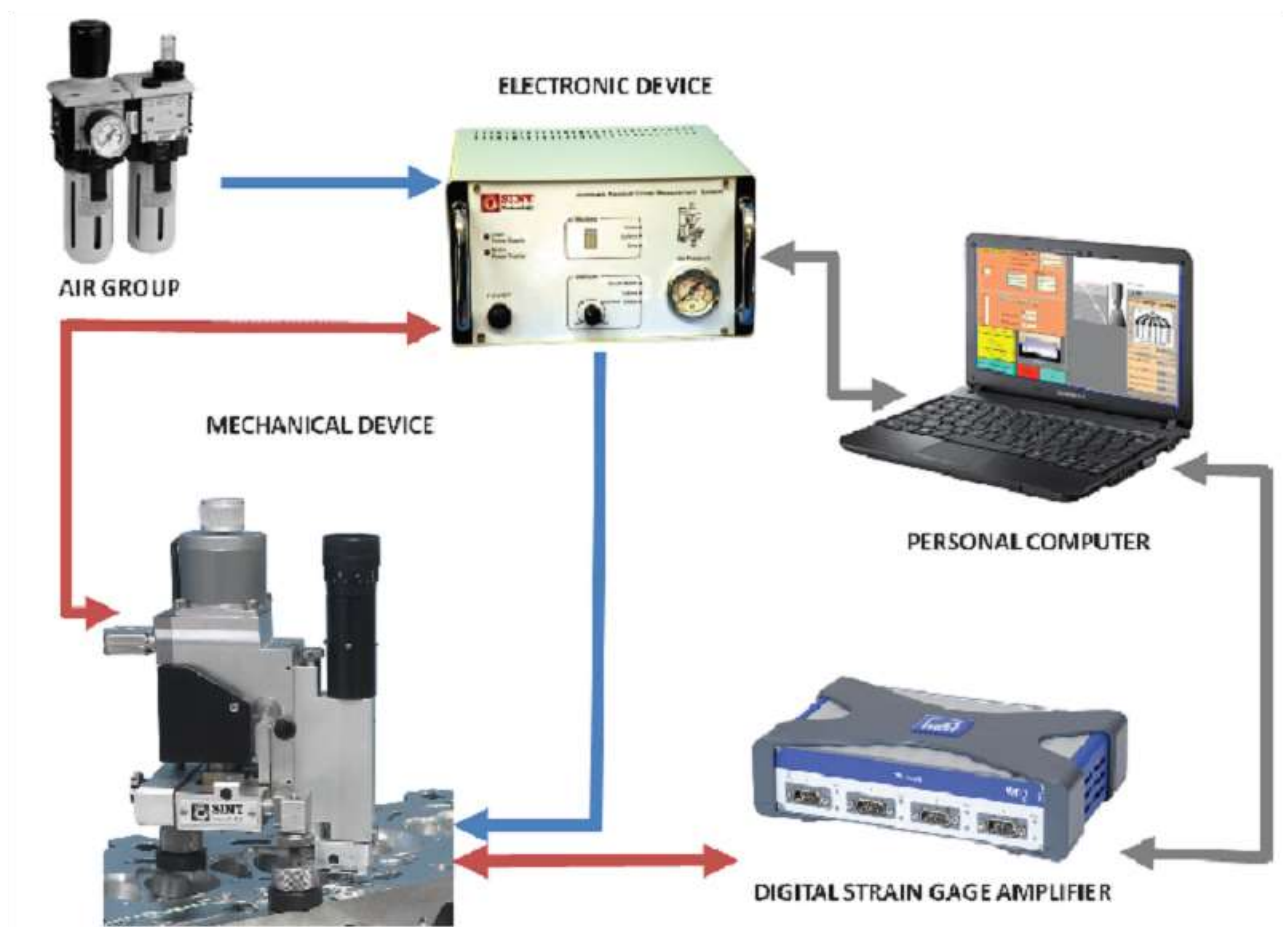


Fig. 1.1 - Standard configuration, measurement chain

1.3. Mechanical-Optical Device

The mechanical-optical device (Fig. 1.2, Fig. 1.3 and Fig. 1.4) consists of a small triple-axis base fitted with a microscope (**Part n° 13**, Fig. 1.4) and a high-speed turbine (**Part n° 6**, Fig. 1.4).

The optical system is used both for centering the drilling axis in relation to the center of strain gauge rosettes and for measuring the diameter and eccentricity of drilled holes.

The system can be positioned on three axes. It stands on three tilting pads and can be tilted to align with the surface of the test specimen. In extreme cases where the magnetic feet are not sufficient, the system has to be secured by fixing the feet in position with a special adhesive (eg, HBM X-60).

On request it's possible to use strong magnetic feet that allow to realize hole drilling test also on vertical walls (1-SINT-FEET, chapter 6.7).

The feet are connected to the body of the device by threaded rods, which are used for height adjustments so that the head of the system is vertically aligned with the surface of the specimen. An L-square may be helpful in some cases.

The base of the system consists of two connected slides. They move on hardened steel pins and precision bearings, so that there is no end play. The horizontal slides are operated manually by means of fine-pitch threaded knobs (**Part n° 14**, Fig. 1.3) and movements are measured by centesimal dial gauges.

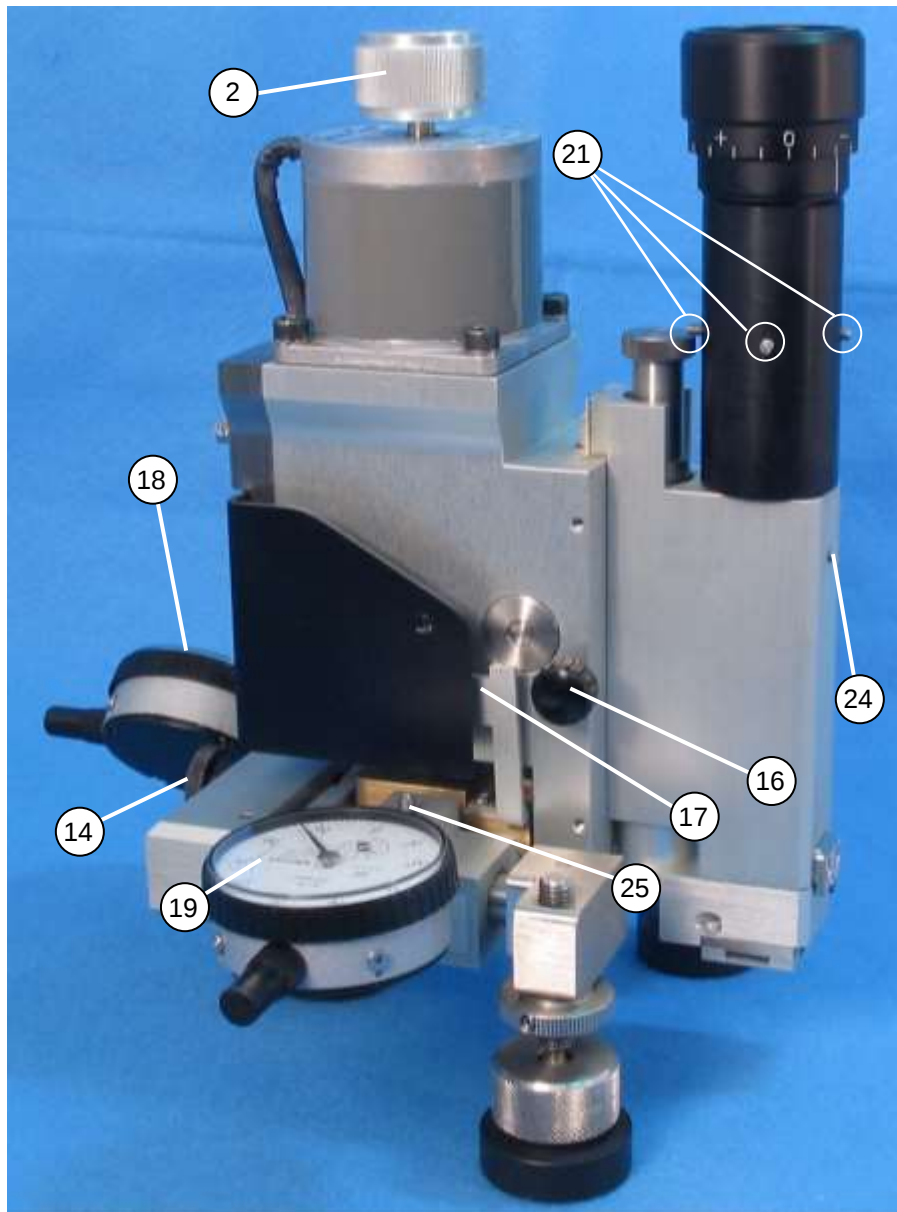


Fig. 1.2 - Mechanical-Optical System

- | | |
|---|--|
| 2 – Slow manual feed control | 21 – Socket head screws for aligning the microscope during calibration. |
| 14 – Horizontal adjustment, Y-axis | 24 – Socket head screw for fixing the microscope in position |
| 16 – Vertical slide lock | 25 – Socket head screw for locking the X-axis dial gauge |
| 17 – Limit switch | |
| 18 – Y-axis dial gauge | |
| 19 – X-axis dial gauge | |

The vertical slide is moved by a rack-and-pinion system operated by an adjustment knob (**Part n° 9**, Fig. 1.3) and locked by a knob on the side of the vertical slide (**Part n° 16**, Fig. 1.2). Fine movement can either be manual (**Part n° 2**, Fig. 1.2) or automatic, by a computer controlled stepping motor (**Part n° 1**, Fig. 1.3).

In both cases, high precision is achieved with a fine-pitch threaded pin (0.500 mm).

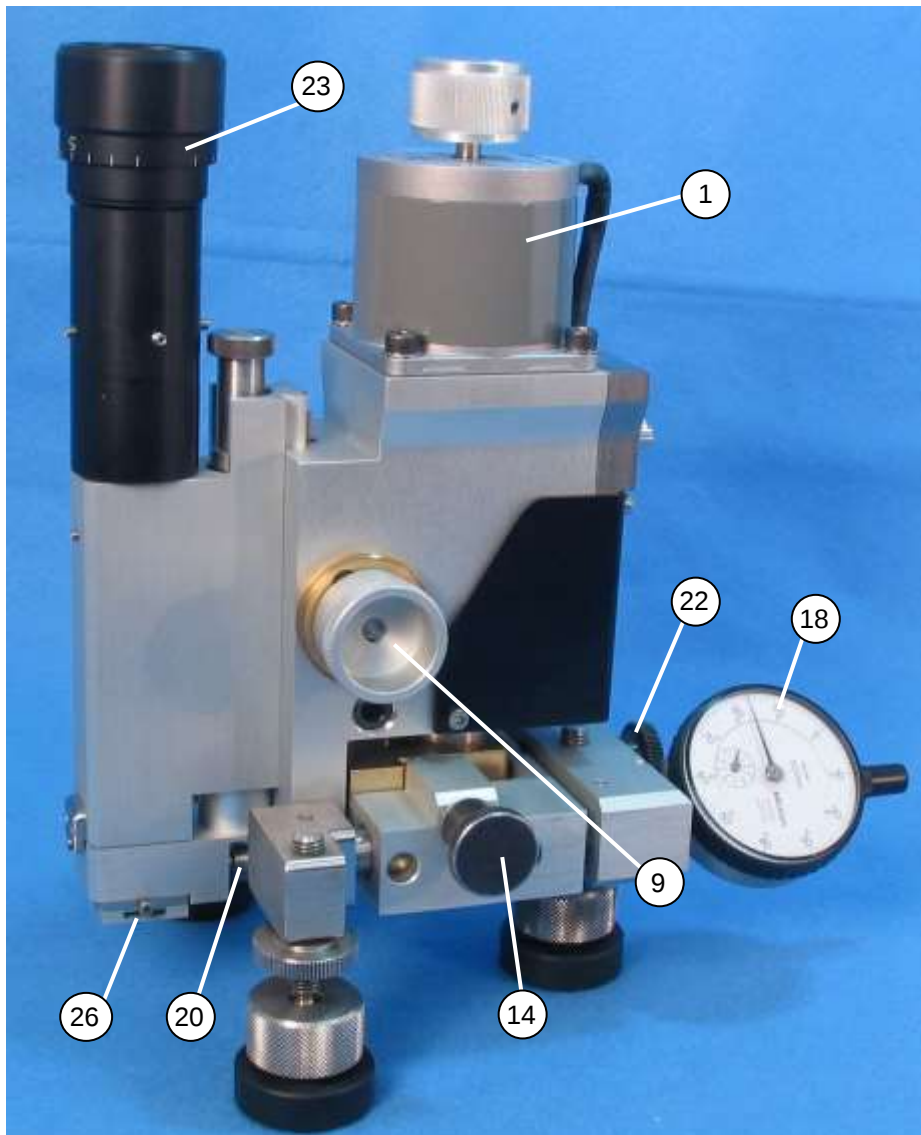


Fig. 1.3 - Mechanical-Optical System

- | | |
|---|--|
| 1 – Stepping motor | 22 – Socket head screw for fixing the Y-axis dial gauge in position |
| 9 – Vertical adjustment | 23 – Eyepiece |
| 14 – Horizontal adjustment, X-axis | 26 – Screw for alligator clip (zero setting) |
| 18 – Y-axis dial gauge | |
| 20 – Compressed air connection | |

A pair of limit switches (**Part n° 17**, Fig. 1.2) limits the travel of the system to prevent any damage.

During drilling the high-speed turbine is positioned perfectly aligned with the microscope. When inspection or optical centering procedures are being carried out, the turbine can be turned allowing viewing by the microscope. To turn, press the knob (**Part n° 4**, Fig. 1.4) and turn approximately 45°.

The air turbine is installed so as to minimize overall dimensions and rotates at a speed of 400'000 RPM. The mills normally used are inverted truncated-cone shaped with a flat end, with a maximum shank diameter of 1.60 mm. The turbine is connected to the compressed air supply by a flexible tube (**Part n° 2**, Fig. 1.3).

The system includes a pressure reducer with a pressure filter-control, a pressure gauge and an on-off ball valve. The valve is installed on the electronic control system which controls it by the RSM control software.

The microscope has a dual function: primarily, it is used for checking that the end mill is aligned with the reference points on the strain gauge rosette; and also for inspecting the hole and measuring the final hole diameter.

The hole diameter can be measured due to the system of movement along two axes with the aid of two dial gauges, plus the target fitted in the eyepiece of the microscope.

The microscope, purpose-made for this device, has a special system for changing the position of the eyepiece and of the target in relation to the drilling axis.

The eyepiece is regulated by means of four socket head screws, spaced 90° apart (**Part n° 21**, Fig. 1.2), which allow the target support to be turned and locked in the desired position.

This allows an initial adjustment to be made, to guarantee alignment between the end mill drilling axis and the center of the target which must be set with the axes parallel to the two directions of movement X and Y.

It should be noted that this target is the reference point for positioning and aligning the mechanical-optical system and for the strain gauge rosette.

The two dial gauges measure the horizontal movement of axes X and Y to a 0.01 mm resolution.

Their total travel is 10 mm, whereas the maximum travel in direction X and Y is 9 mm.

The dial gauges are mounted to cover the whole travel distance and can be set to zero in any position. Both dial gauges are fixed on the supports by tightening the socket-head screws with a set screw wrench (**Part n° 22**, Fig. 1.3).

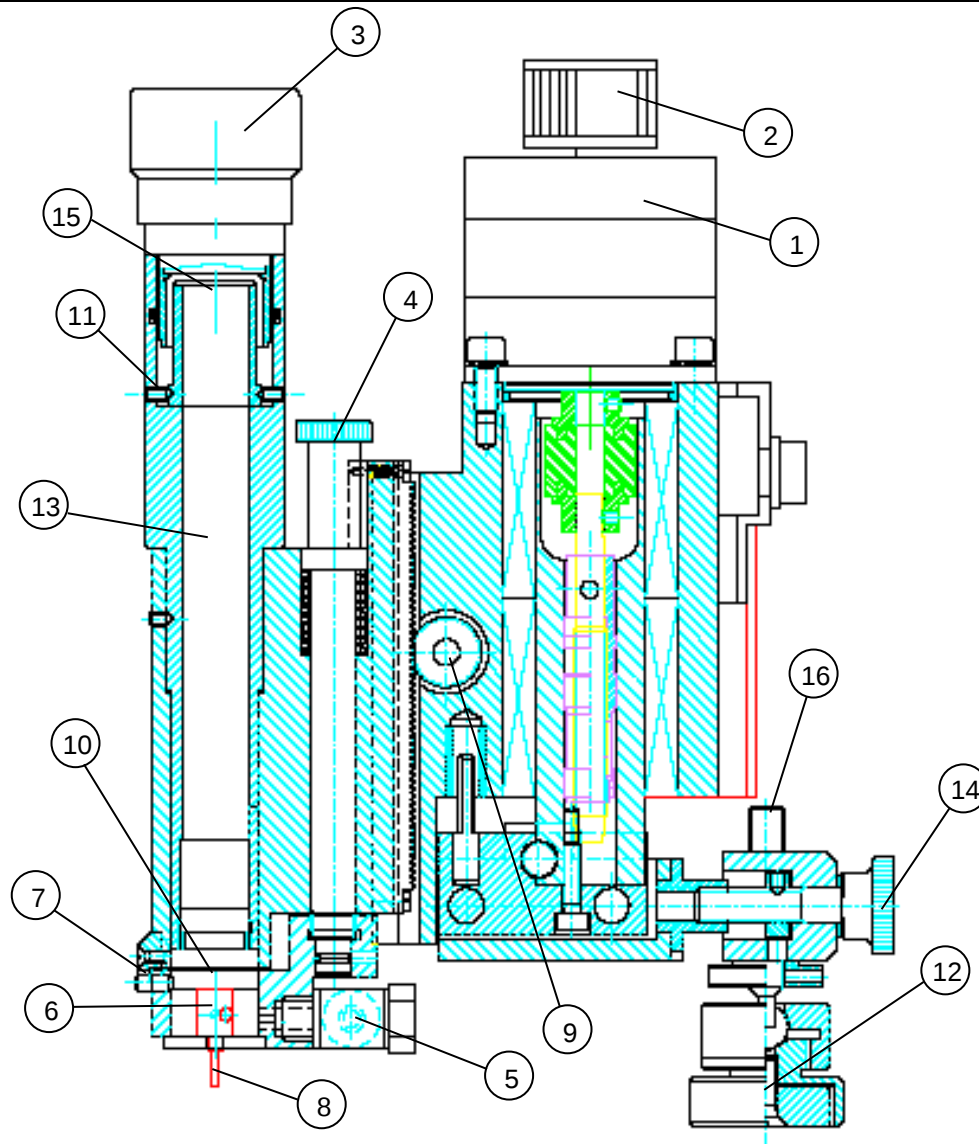


Fig. 1.4 - Mechanical-Optical Device – Cross Section

- | | |
|--|---|
| 1 - Stepping motor for automatic fine speed control | 9 - Knob for fast vertical feed |
| 2 - Knob for manual operation of the stepping motor | 10 - Back cap for closing the turbine |
| 3 - Eyepiece | 11 - Socket-head screws for calibrating the optical device |
| 4 - Turbine release | 12 - Support of the feet |
| 5 - Compressed air connection | 13 - Microscope |
| 6 - Air turbine | 14 - Horizontal adjustment knob |
| 7 - Spindle | 15 - Eyepiece target |
| 8 - End mill | 16 - Vertical adjustment threaded pin |

1.4. Electronic Control System

The electronic control system allows the mechanical-optical fixture to be controlled by the control software.

It is made up of the following components:

- Regulated power supply as required for: (a) the stepping motor; (b) the signals for controlling the mechanical system
- Stepping motor control unit
- PC interface system
- Compressed air operation and control system.

The front panel of the electronic control system is shown in Fig. 1.5 herebelow.

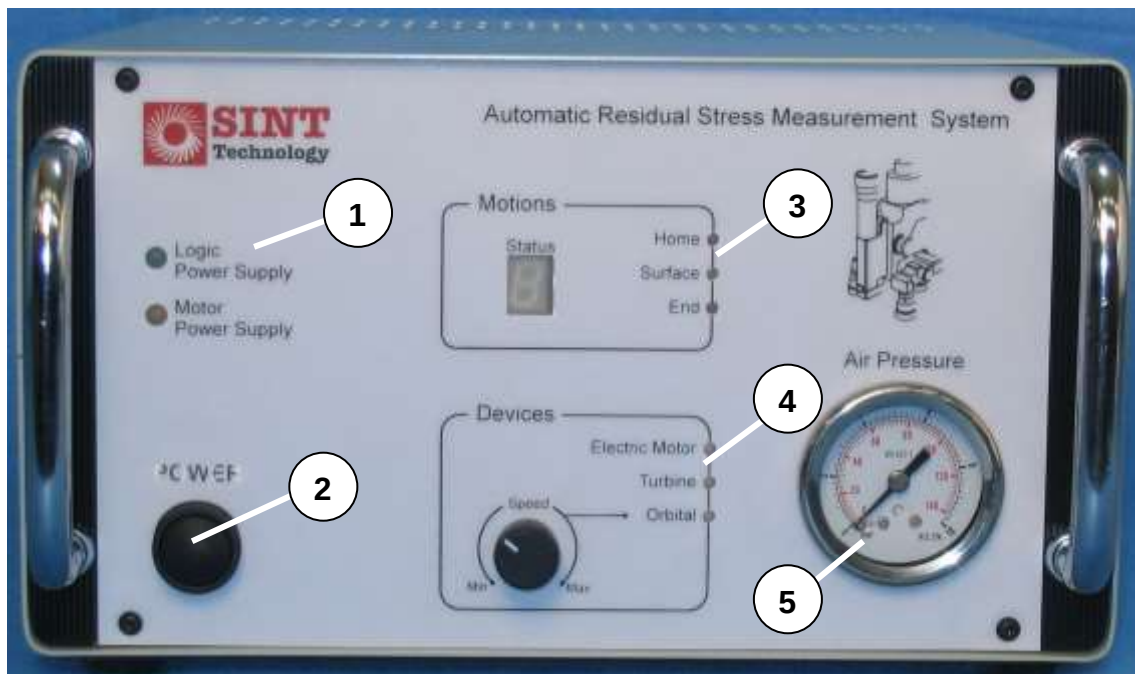


Fig. 1.5 - Front panel of the electronic control system

On the front side, the user can find:

- 1 The Logic Power Supply and Motor Power Supply pilot lights;
- 2 The Electronic control system power button;
- 3 The status of the mechanical-optical system, of the home limit switch, the end limit switch and identification of the specimen surface/zero level. The coding of the 7-segment status indicator is illustrated in Chapter 7;
- 4 The system-on indicators, the electric driver (Electric Motor), the standard system with a compressed air turbine (Turbine), the system with orbital compressed air turbine operation (Orbital), and the orbital speed control (Speed);
- 5 The pressure gauge showing the pressure of the compressed air supply to the turbine during operation.

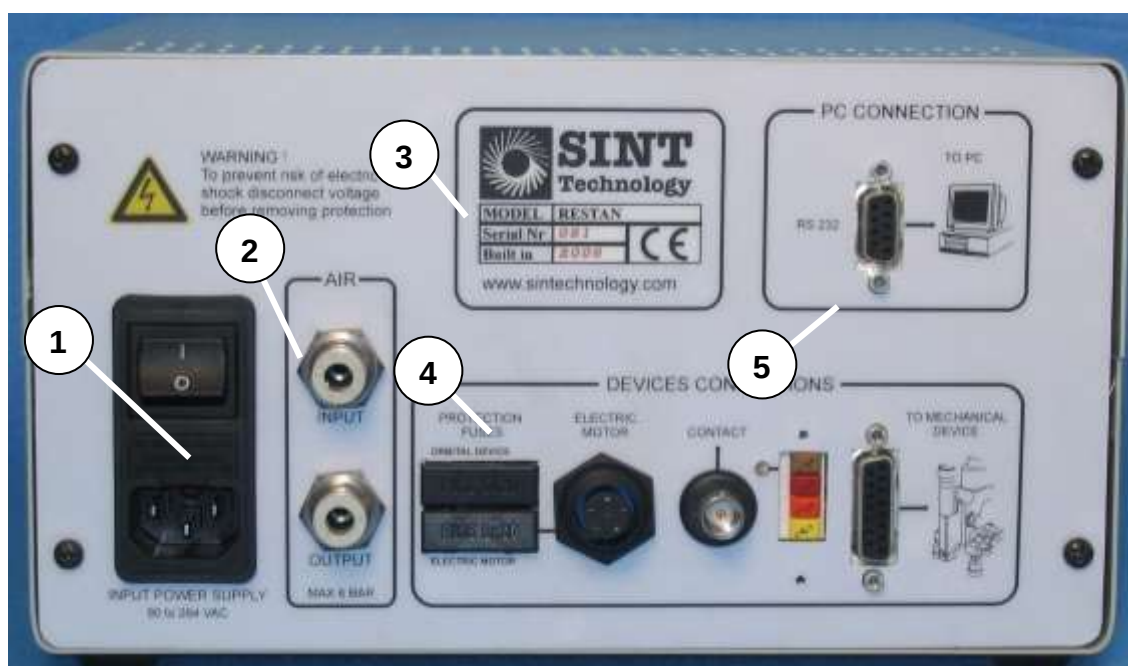


Fig. 1.6 - Rear panel of the electronic control system

On the rear panel (Fig. 1.6) the user can find:

- 1 The power supply unit (90-264V, 50-60Hz), comprising the electronic control system power switch, a basket for the line traps, and a power lead connection;
- 2 The compressed air input and output connections;
- 3 The electronic control system identification data;
- 4 A set of connections to the mechanical unit, passive protections and selectors, specifically the fuses for the orbital system and electric motor, the electric motor connector, the BNC connector for identifying the zero level on the specimen, the selectors for setting the electronic system hardware, the DB25 connector for the connection with the mechanical system.
- 5 Connector RS 232 for connecting the electronic control system to a PC.

**WARNING:**

To switch the electronic device off, and to avoid its accidental shutdown, press the button (Part n° 2, Fig. 1.4) for at least 5 seconds.

**WARNING:**

Remember to disconnect the cable for the connection with the mechanical system only when the electronic device is switched off.

**WARNING:**

The compressed air supply must come from the pressure control and filtering unit and must not exceed 6 bar. The inlet pressure to the

compressed air turbine must be between 3.5 and 5 bar.

1.5. Control and data acquisition program

Control of operation and data acquisition are effected by means of specially developed software, the electronic control unit and the strain gage amplifier (analog or digital).

All of the functions can be selected from a window by keys. Each key has a specific function, which is described on the same graphic window. The keys can be selected using a mouse. It is possible to return to the previous window by pressing the Escape key (ESC). This is a simple way to exit from the program should it not be possible to use a mouse.

The input data is entered by selecting the appropriate box and the type of data contained in it with a mouse. In addition, when data is acquired, it is not necessary to click on RETURN as the data is acquired automatically.

The main program is called "**RSM.EXE**".

The windows shown in the following figures allow the main operations to be performed:



Fig. 1.7 - Main Menu

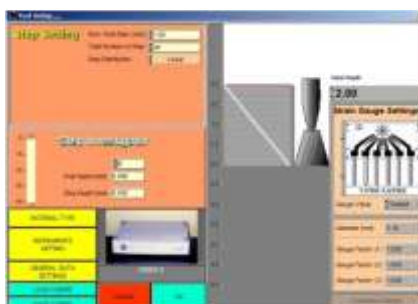


Fig. 1.8 - Test setup



Fig. 1.9 - Test manager

A detailed description of all the software functions is provided in Chapter 4 of this manual.

For each stage there is a standard procedure, which the software executes as default, unless otherwise specified. Normally the default procedures are those recommended.

With this system, a large number of depth increments can be achieved with high accuracy making it possible to determine a curve of relieved strains through using test points. Application of a calculation procedure for a better interpolation may serve to improve the stability and quality of the end result.

The RSM software allows to set the best parameter for the measurements chain and allow to set drilling steps up to 5 μm and acquire automatically the strain for each drilling step with an automatic procedure (without any human influence).

1.6. Evaluation software

**NOTE:**

The EVAL is usually provided with the manual version of the MTS3000-Restan system in its Basic version: for an upgrade of this software version or for any additional information, please refer to the EVAL manual or contact the SINT Technology technical support team (support@sinttechnology.com)

The evaluation software (EVAL) is the software used for the calculation of residual stress starting from the acquired data (strains, depth and hole radii): this software can be provided in different versions that differ for calculation and correction algorithms, and additional software features (graphical interfaces).

The minimum number of hole-drilling increments is 10, as indicated in Standard ASTM E837-13 for uniform stress in the depth. However, the best results are obtained with 40 or more (we suggest 40 in the first 2 mm, each step of 0.05 mm).

In the old version of the standard (ASTM E837-08) the minimum number of hole-drilling increments is 8, as indicated for uniform stress in the depth. However, the best results are obtained with 40 or more (we suggest 40 in the first 2 mm, each step of 0.05 mm).

Calculation of the best interpolation (best fit) of the data is conditioned by determination of the polynomial coefficients, which is done by the least squares method. It is then possible to select the degree of polynomial interpolation for each set of data recorded for the three strains measured as a function of hole depth. The software determines by default the best possible degree of the interpolating polynomial through using an optimization procedure.

The software disposes of the following procedures for calculating residual stresses:

- Standard ASTM E837-13: uniform stress field
- Standard ASTM E837-13: non-uniform stress field
- Standard ASTM E837-08: uniform stress field
- Integral method
- Kockelmann method
- HDM method

The procedures have different fields of application and the following notes should be taken into consideration in deciding which is the most appropriate method.

The EVAL software includes also a large variety of correction algorithms for minimizing the effects of the more common errors made in these measurements.

Particularly, the EVAL software introduces the correction for eccentricity errors between the drilled hole and the center of the strain gage rosettes and the correction for the plasticity effects around the drilled hole.

1.6.1. ASTM E837-13 method for uniform stress fields

This is the method described in standard ASTM E837-13, based on the assumption that stresses do not vary with distance from the surface of the workpiece.

This method has to be used when preliminary calculation results demonstrate that the stress field is uniform with depth or if you need a preliminary indication of the amplitude of residual stress.

For this reason, the method does not consider spatial resolution. Nevertheless, when measured residual stresses are in fact uniform, this is the method to choose, because it is the least sensitive to the effects of test errors.

The ASTM E837-13 standard establishes 10 acquisition depth steps to a total of 1.00 mm, each one of 0.10 mm (using a strain gage rosette of approximately 5.13 mm of strain diameter). The calculation method is strictly valid for computed stresses up to 80% of the yield stress of the material for a “thick” workpiece and 60% for a “thin” workpiece.

1.6.2. ASTM E837-13 method for non-uniform stress fields

This calculation method is described in standard ASTM E837-13, based on the assumption that stresses vary with distance from the surface of the workpiece.

This method has to be selected in the case of a non-uniform stress field in hole depth and the output of the calculation is a plot of residual stresses in the hole depth.

The numerical coefficients established by ASTM E837-13 are used for the calculation. The maximum depth that the method can be used for is 1.00 mm (using a strain gage rosette of approximately 5.13 mm of strain diameter): in this case the ASTM E837-13 standard establishes 20 acquisition depth steps, each one of 0.05 mm. The number and the distribution of the calculation steps are fixed by the ASTM E837-13 standard. The experimental errors in the calculation are minimized using the Tikhonov regularization algorithms.

1.6.3. ASTM E837-08 method for uniform stress fields

This is the method described in standard ASTM E837-08, based on the assumption that stresses do not vary with distance from the surface of the workpiece.

Before starting with the calculation, a uniformity test defines the type of stress field.

For this reason, the method does not consider spatial resolution. Nevertheless, when measured residual stresses are in fact uniform, this is the method to choose, because it is the least sensitive to the effects of test errors.

The ASTM E837-08 standard establishes 8 acquisition depth steps in the first 2.00 mm, each one of 0.25 mm (using a strain gage rosette of approximately 5.13 mm of strain diameter). The calculation method is strictly valid for computed stresses up to 60% of the yield stress of the material.

1.6.4. Integral method

This method provides a separate residual stress analysis at every hole drilling depth increment.

The integral method should be chosen when residual stresses are expected to vary significantly with depth; however, it also has the highest sensitivity to test errors. This problem quickly gets worse when you try to raise the spatial resolution increasing the depth increments. The numerical coefficients established by Schajer are used for the calculation. The maximum depth that the method can be used for is 0.5 times the mean radius of the strain rosette used for the test.

The system's software allows you to select the number and distribution of depth increments, whereas these parameters are established by the ASTM standard in the non-uniform stress method. The distribution of the calculation steps may be constant or variable.

1.6.5. Schwarz-Kockelmann method

This method uses the numerical coefficients calculated by Kockelmann and allows you to reach a calculation depth equal to 1.00 mm (using a strain gage rosette of approximately 5.13 mm of strain diameter). It is a method which has little sensitivity to the effects of test errors but it is valid only in a very particular case of rosette diameter and hole diameter where $D/D_0 = 3$.

Recently, also coefficients for different values of D/D_0 have been provided and included in the EVAL software.

The system's software allows you to select the number and distribution of depth increments, whereas these parameters are set by the ASTM standard in the non-uniform stress method. The distribution of the calculation steps may be constant or variable.

1.6.6. HDM method

The HDM Method was originally proposed by the University of Pisa in the nineties as an improvement of the Integral method.

It is based on three equations proposed by the Integral method and it has been generalized by analytical definition of the influence functions.

This main advantages of the HDM method are the parametric description of the strain gage rosette which eliminates dependence on the model of rosette used, the greater accuracy in calculation of the influence coefficients in relation to the values provided by the Integral method, and the possibility of correcting the effect of hole-rosette eccentricity.

Moreover the HDM Method makes it possible to describe the state of stress within a component with several functions, in order to reconstruct the experimental measurements more accurately by using spline functions, directly inserted into the integral equations, to use an optimization algorithm which takes account also of the effects of experimental

measurement errors and to minimize the effect of experimental measurement errors by solutions which are no longer direct but based on statistical instruments, such as the least squares method, introducing more experimental measurement points in each stress calculation.

The maximum depth that the method can be used for is 0.5 times the mean radius of the strain rosette used for the test.

The system's software allows you to select the number and distribution of depth increments, whereas these parameters are established by the ASTM standard in the Non-Uniform Stress Method. The distribution of the calculation steps may be constant or variable.

1.6.7. Algorithms for correction of eccentricity errors

Eccentricity errors are the most common type of errors that can be made during a hole drilling measurement.

The influence of eccentricity errors can reach 5% in the case of eccentricity of 0.05 mm (using a strain gage rosette of approximately 5.13 mm of strain diameter): this value is exactly double the acceptable limit reported in the ASTM E837-13 standard.

1.6.8. Algorithms for correction of the plasticity effect around the drilled hole

A parameter that can introduce significant errors in calculation of residual stress is the ratio of residual stresses to the material yield stress.

The presence of the drilled hole introduces locally, in the case of residual stresses higher than the suggested limit, an overestimation of the residual stress field that changes from elastic to locally plastic.

According to the ASTM standard, depending on this stress ratio, the acceptable limits are the following:

- ASTM E837-13 – Uniform stress field – “Thin” workpiece: 50%
- ASTM E837-13 – Uniform stress field – “Thick” workpiece: 80%
- ASTM E837-08 – Uniform stress field : 60%

The algorithms allow this kind of error to be corrected in the case of a uniform residual stress field in the tested workpiece.

2. TECHNICAL DATA / REQUIREMENTS

2.1. *Mechanical-Optical Unit:*

• Max. Height	mm	270.0
• Max. Width	mm	150.0
• Max. Length	mm	170.0
• Weight	kg	4.6
• Maximum speed of the turbine	RPM	400,000
• Maximum useful diameter of the end mill	mm	2.00
• Air pressure in the turbine	bar	3.5 ÷ 5.0
• Fast vertical travel	mm	60.0
• Fine vertical travel (motor controlled)	mm	6.00
• Horizontal travel on axes X and Y	mm	9.00
• Turn of the turbine from the drilling position	°	45
• Maximum height adjustment of the feet	mm	60.

2.2. *Electronic Unit:*

• Max. Height	mm	140.0
• Max. Width	mm	245.0
• Max. Length	mm	220.0
• Weight	kg	5.4
• Power supply	V	90 - 264 50 - 60 Hz
• Max. compressed air pressure input	bar	6.0
• Fuse	A	1.5
Continuous acoustic pressure level (at 1m)	dBA	76.0

2.3. *RSM and EVAL Software:*

• OS Platform	Windows
• OS Version	XP, Vista, 7, 8, 8.1

2.4. PC requirements

Following the minimum system requirements for the RSM software are reported:

- **OS:** Windows Vista, 7 and 8
- **MEMORY:** 1 Gb or more (suggested 2 Gb)
- **HDD FREE SPACE:** 1 Gb or more
- **SCREEN RESOLUTION:** 1024x600 or higher
- **PORT:** 2 USB ports or more
1 Gigabit Ethernet port (RJ45)

For any further information, please contact support@sinttechnology.com.

2.5. Application and restrictions

The system has been designed for performing tests to evaluate residual stresses by the blind hole technique, using strain gauge rosettes, either in accordance with Standard ASTM E837-13 for uniform and not uniform stress distribution within the total hole depth, or in accordance with the procedures for evaluation of non-uniform stress provided in technical literature.



WARNING:

Testing can be conducted on any component or material as long as hole drilling does not put the operator, other people or property at risk and does not affect future operation of the system or the components of the system.

The system can only be used for precision milling due to its high accuracy in operation.



WARNING:

Use of the system for any other purpose is strictly prohibited. The manufacturer shall not be held liable for any damage caused by using the system for operations that are not illustrated in this manual (improper use) or by incorrect use (eg, not in accordance with the instructions provided in this manual).

2.6. Hazards and precautions

The system has been designed to perform tests for the evaluation of residual stresses by the hole-drilling strain gauge method in compliance with health and safety standards and EC Directives.

The system conforms to the Machinery Directive (89/392/EEC) and following amendments – as stated in the Declaration of Conformance – and to the Low Voltage Directive (73/23/CEE) and its amendments.

Also the following harmonized technical standards have been applied: EN 292, EN 414, EN 1050, EN 60204-1.

**WARNING:**

To prevent electrical shock, disconnect the system from the mains before removing any protective devices.

**WARNING:**

There is a remote risk of flying chips during the milling process, with the consequent risk of eye injury when the operator is very near the mechanical device. To reduce these risks, it is advised and recommended that operators checking the drilling process wear eye protection throughout all operations in hazardous conditions as indicated on the machine. All conditions requiring the use of eye protection are listed in Section 5.1.

**WARNING:**

Do not wet the electronic unit and do not use it outdoors in rain or snow.

**WARNING:**

The manufacturer shall not be considered liable for any damage caused by failure to follow these safety regulations.

**NOTE:**

The quality of the air supply to the turbine is very important. It is therefore advisable to use a dedicated compressor. The compressor may be oil-free. If not, filters are required to remove any particles of oil.

Downstream from the compressor there should be a prefilter (for example, a ceramic filter to trap particles down to 3 to 5 microns in diameter) and especially a dryer to cool the compressed air and eliminate residual water vapor. The best dryers are adsorption dryers. Standard cooling-cycle dryers could be used instead although the residual quantity of water vapor would be greater.

An ultra-fine filter unit should be fitted downstream from the dryer. It should comprise either one or two fine filters to remove liquids and solid particles and an activated carbon filter to remove residual oil.

Lastly, additional filters are fitted on the pressure control provided with the system to trap solid particles and liquids.

Omitting any of these elements in the air supply system shortens the duration of the next element in the chain.

3. OPERATING AND MAINTENANCE INSTRUCTIONS

3.1. *Transport and cleaning*

The system is provided with a trolley carrier case. The case weighs about 18 kg with the system stored inside it and can therefore be easily transported.



Fig. 3.1 - Mechanical system stored inside the carrier case.

The carrier case should always be used for transporting or shipping the tool as it is specially designed to hold it (Fig. 3.1). If it is to be forwarded by a carrier company, it should be packed in a cardboard box for extra protection.



WARNING:

Damage-free transportation is assured by properly fitting the tool in the carrier case and by ensuring that there are no loose parts inside the case.

The unit should be cleaned if used regularly, particularly in industrial premises, in order to maintain the system in efficient working conditions and prevent any damage or deterioration caused by dirt.

The electronic control system and the mechanical unit should be cleaned using a damp cloth or a dry cloth on the mechanical unit and the casing of electronic system and a dry cloth or brush on the front and rear panel of the electronic control system and on all electrical parts in general.

**WARNING:**

Never spray liquid detergent or water directly above the electronic control system.

Never use chemical solvents.

When the system is used, dirt can build up and affect the efficiency of the microscope. To keep this fundamental part of the system efficient, it should be cleaned regularly, always taking care to:

- Blow on the lenses with filtered compressed air, so that there is no dust or traces of oil in it, or with a nitrogen can before cleaning;
- Always use clean cotton cloths moistened with colorless pure alcohol. Never use denatured alcohol as the pigments added for coloring leave a ring on the lens.

Any optical parts showing signs of mold should be replaced.

**WARNING:**

Never disassemble the microscope.

If you think there is a build-up of dirt inside it or if there are spots of damp or grease, contact Customer Assistance at SINT Technology (support@sinttechnology.com)

The compressed air unit, provided with the electronic control system, is made up of a pressure reducer with its pressure gauge and filter (5 μm), air filter (0,01 μm) and residual water/oil filter (0,1 mg/m^3).

The air filter needs to be cleaned regularly, depending on the ambient conditions it is used in (quality of the air in the supply system).

A good routine practice would be to:

- Open the air filter and remove it (cylindrical spongy material). Check the amount of particles trapped inside.
- If there is an excessive amount, replace with a new filter.

3.2. Software and Hardware installation

The software and hardware have to be installed before the system can be used. Correct installation and set-up of both of these are prerequisites for efficient operation throughout every stage of operation.

The following procedure outlines the operations required for installing the software.

3.2.1. DVD software installation menu

The MTS3000-Restan system is provided with the DVD software installation in which are available the latest version of the system's software and the driver for the communication with the PC and the strain gage amplifier.

Once the DVD is introduced in the PC, double click on the file “**Installer.exe**” and the Software installation menu will appear: in this menu (Fig. 3.2) it's possible to select the software / driver that you need to install.

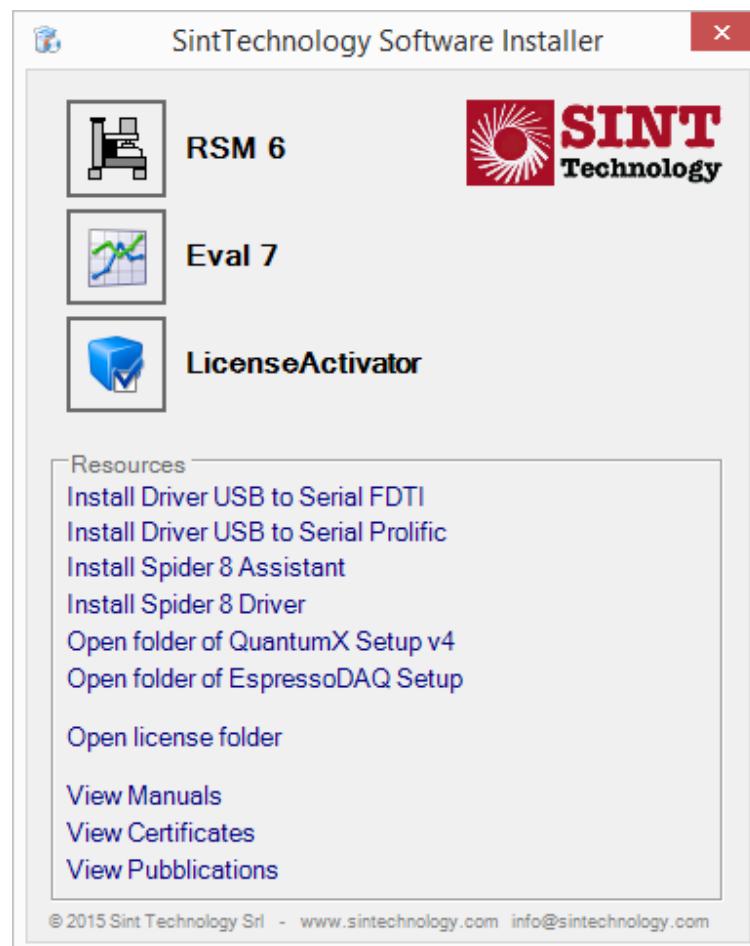


Fig. 3.2 –Software installation menu.



WARNING:

If you use Windows 7 (or higher) as OS, we suggest to “Run as Administrator” the file “**Installer.exe**” of the software installation DVD.

3.2.2. RSM installation

The RSM software is the program that allow the user to control the instrument, to set the test parameters and to acquire the strain from the strain gage rosette.

For the installation of the RSM the following steps has to be performed:

- Click on the icon RSM in the software installation menu
- Wait for some second the preparation of the installation
- Specify the directory for the RSM software and for National Instrument support files and click on “**Next**”
- Accept the License Agreement for National Instrument support files and click on “**Next**”
- Disable the Windows Fast Startup feature (only if the software is installed on OS Windows 8) and click on “**Next**”
- Review the installation details and click on “**Next**”
- Wait the end of the installation process
- Re-start the system at the end of the installation procedure



NOTE:

The installation time depends of the hardware performance of the computer.



WARNING:

Do not shut down the computer during this process: it can cause problems in the installation and the software could not work properly.

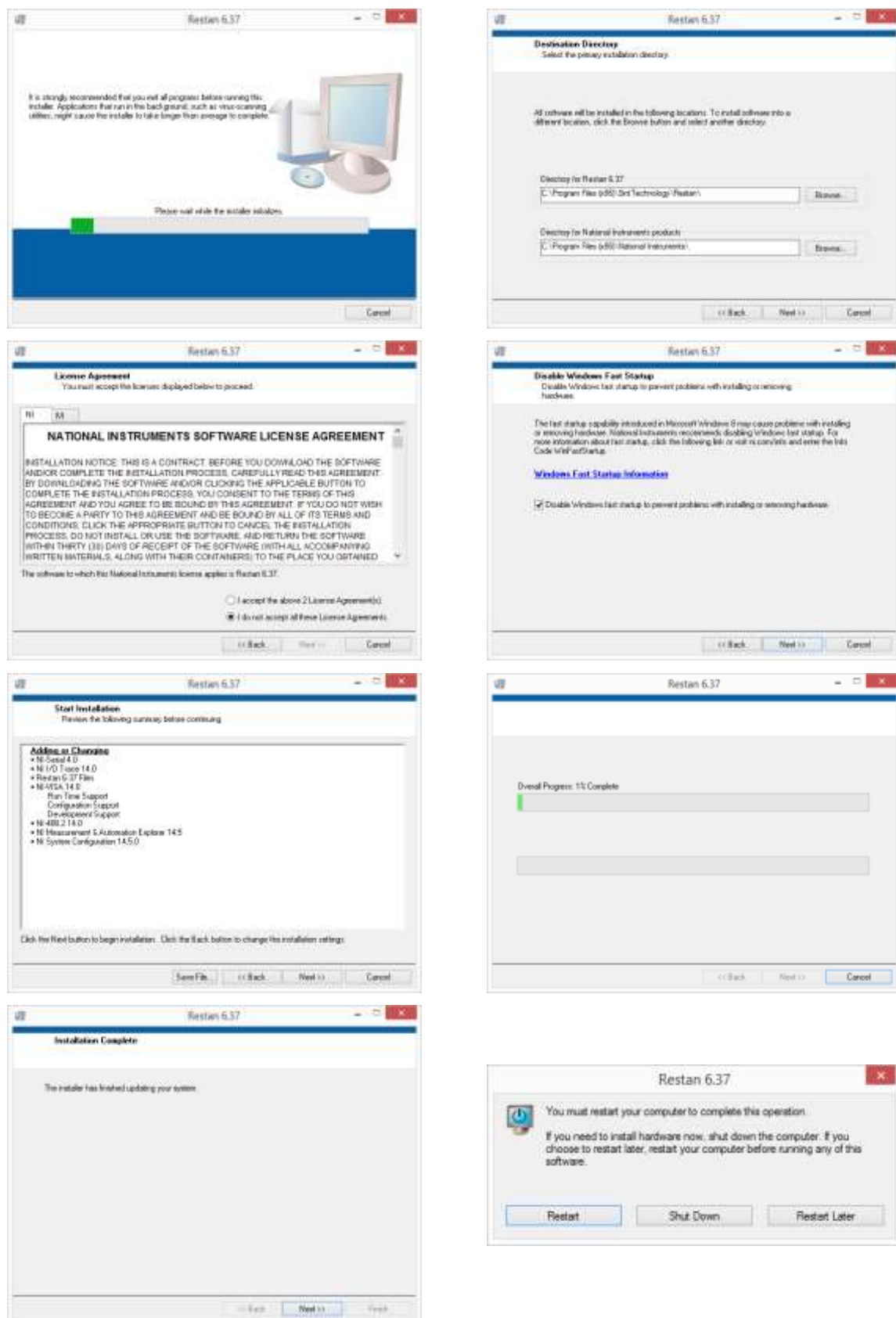


Fig. 3.3 - RSM installation process

3.2.3. EVAL installation

The EVAL software is the program that allow the user to calculate the residual stress starting from the acquired strains.

For the installation of the EVAL the following steps has to be performed:

- Click on the icon EVAL in the software installation menu
- Wait for some second the preparation of the installation
- Specify the directory for the EVAL software and for National Instrument support files and click on “**Next**”
- Review the installation details and click on “**Next**”
- Wait the end of the installation process

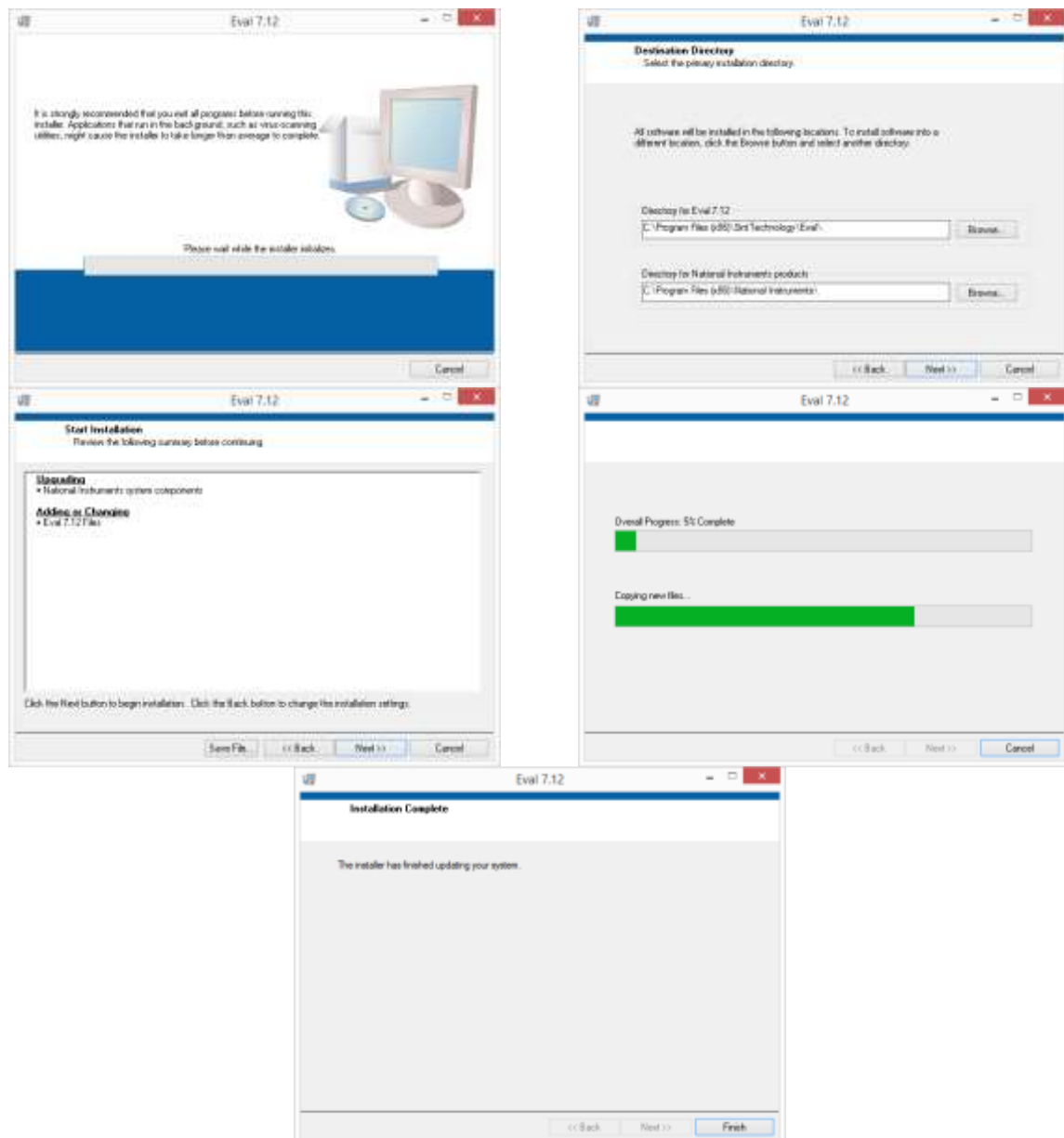


Fig. 3.4 – EVAL installation process

3.2.4. License Activator installation

The License activator software is the program that allow the user to activate the license of the RSM and EVAL software on the PC in which they'll be installed.

For the installation of the License Activator the following steps has to be performed:

- Click on the icon License Activator in the software installation menu
- Wait for some second the preparation of the installation
- Specify the directory for the License Activator software and for National Instrument support files and click on **"Next"**
- Review the installation details and click on **"Next"**
- Wait the end of the installation process

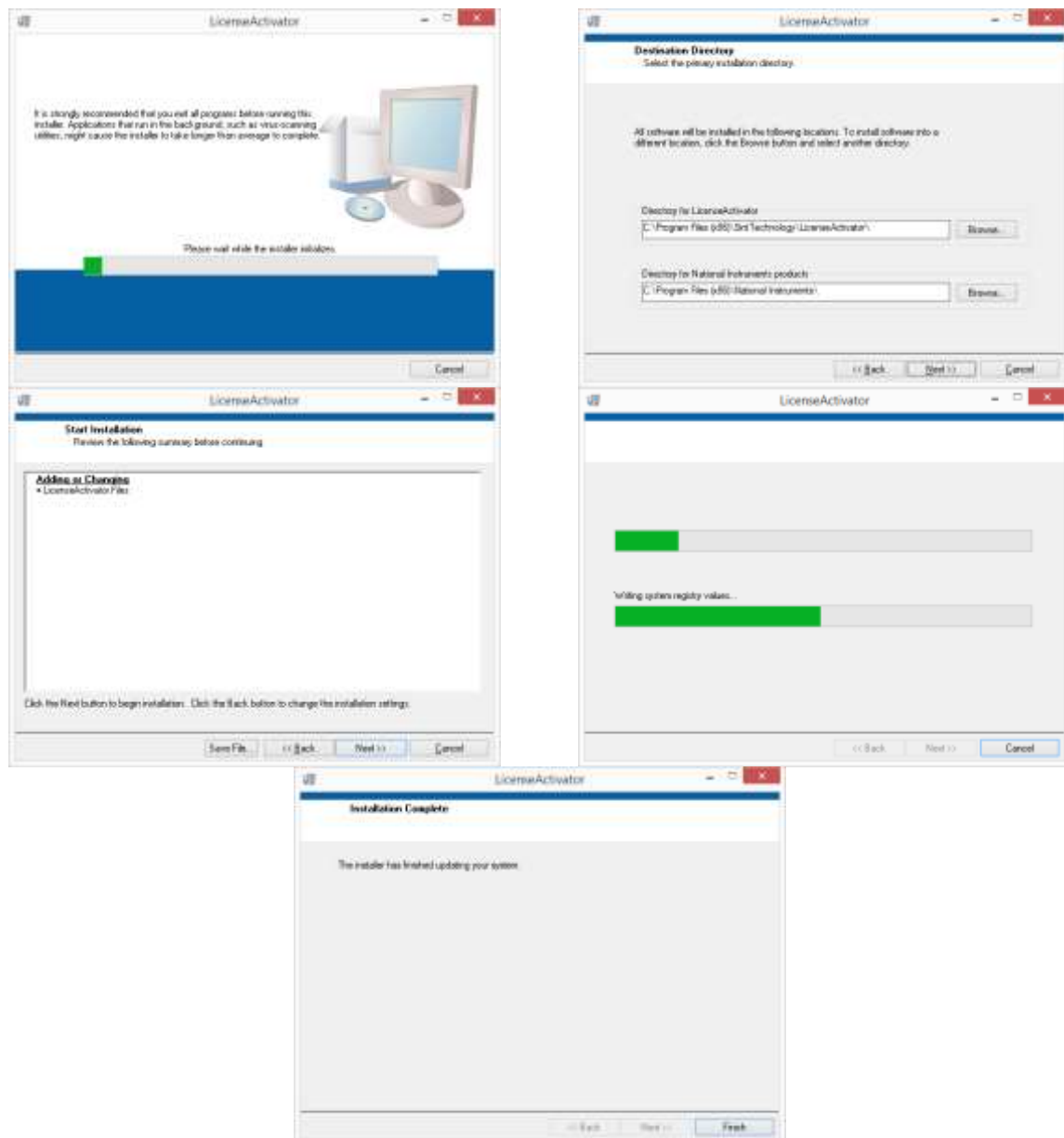


Fig. 3.5 – License Activator installation process

3.2.5. Activation of the RSM and EVAL software

For the activation of the License for the RSM and EVAL software, the following steps has to be performed:

- Launch the Activation software clicking on the file “**LicenseActivator.exe**” located in the specified folder for the installation of the License Activator software.
- Click on the Load/Open icon in the widows that automatically appears.
- Select the License file (.lic) provided by the SINT Technology staff or directly provided on the MTS3000-Restan system Software Installation DVD (folder **080_License**).
- Select the file and click “**Activate**”.

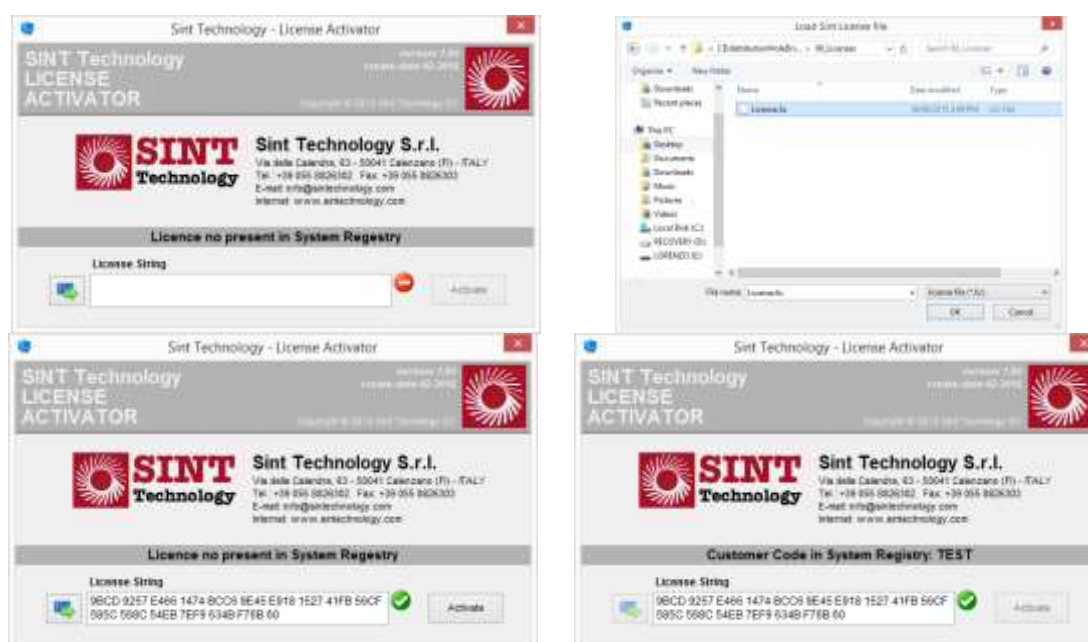


Fig. 3.6 – Activation of the RSM and EVAL license



WARNING:

If you use Windows 7 (or higher) as OS, we suggest to “Run as Administrator” the file “**Installer.exe**” of the software installation DVD.



NOTE:

The licensing system used by SINT Technology for the RSM and EVAL software needs the activation of license provided by SINT Technology staff on the computer in which the software will be installed and its dedicated USB protection key installed on the PC USB port.

The RSM and EVAL license is single user / multi PC.

3.2.6. Installation of the USB to Serial adapter drivers

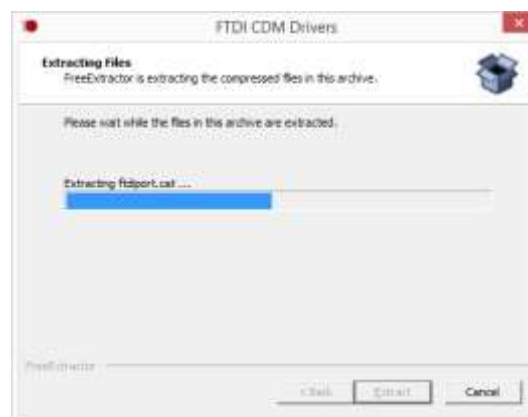
The MTS3000-Restan system uses the serial (RS-232) communication protocol for the communication between the electronic device and the PC and in some cases between the digital strain gage amplifier and the PC.

The connection is done using the USB port of the computer by one (or more) USB to Serial adapter (provided with the system): this adapters need to install a specific driver on the PC.

3.2.6.1. Installation of FDTI Chip USB to Serial adapter (OS Windows 8 or higher)

For the installation of the FDTI Chip USB to Serial adapter the following steps has to be performed:

- Click on the link “**Instal USB to Serial FDTI**” in the software installation menu
- Click “**Extract**” for extracting the driver file on your PC before the installation process
- Wait for some second the end of extraction
- Accept the License Agreement and click on “**Next**”
- Wait for some second the end of the installation of the driver
- Verify the presence of the green flag on the installation status and click “**Finish**”
- Introduce the USB to Serial adapter in the USB port.



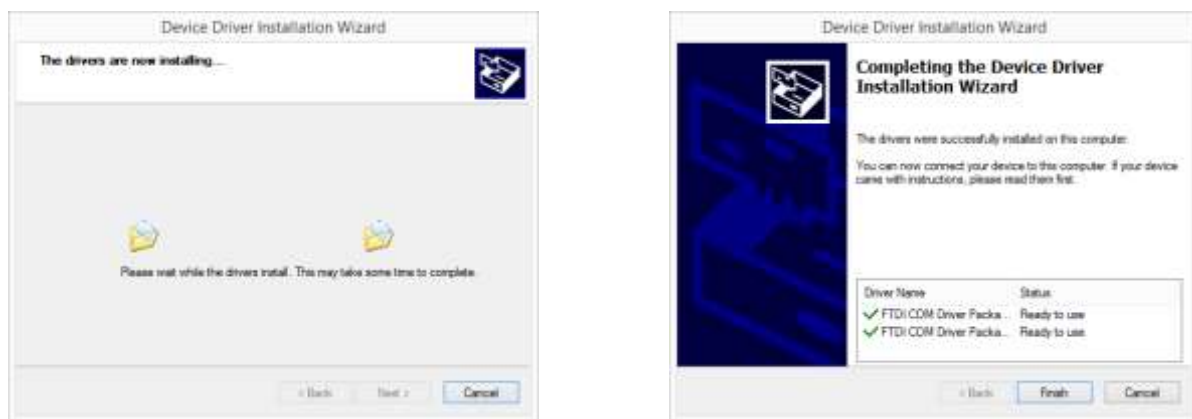


Fig. 3.7 – Installation of the FDTI Chip USB to Serial adapter driver

3.2.6.2. *Installation of the Prolific USB to Serial adapter (OS Windows Vista/7)*

For the installation of the Prolific USB to Serial adapter the following steps has to be performed:

- Click on the link “**Instal USB to Serial Prolific**” in the software installation menu
- Click “**Next**” for starting the installation process
- Wait for some second the end of extraction
- Click “**Finish**” and introduce the USB to Serial adapter in the USB port.

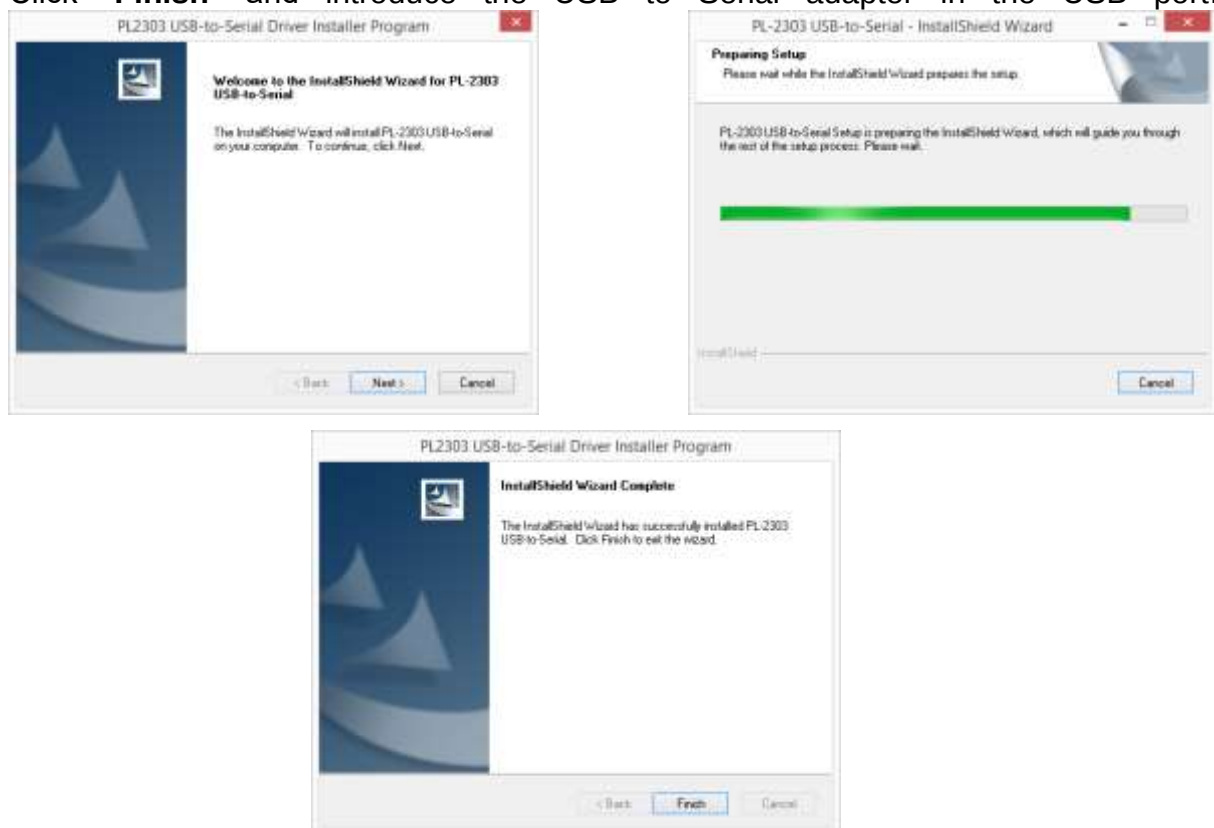


Fig. 3.8 – Installation of the Prolific Chip USB to Serial adapter driver

3.2.7. Installation of the strain gage amplifier drivers

The MTS3000-Restan system uses a digital amplifier for the acquisition of the strain from the strain gage rosette. Depending of the strain gage amplifier type, the connection will be done using the USB to Serial adapter or the TCP/IP protocol using the Ethernet connection.

The main amplifier supported by the RSM software are:

- HBM Spider 8
- HBM Spider 8.30
- HBM QuantumX MX440
- HBM QuantumX MX840
- HBM QuantumX MX1615
- HBM Espresso DAQ DQ-430

3.2.8. Install Spider 8 Assistant and driver

For the installation of the Spider 8 Assistant and driver the following steps has to be performed:

- Click on the file “**Setup.exe**” in the folder “**06_Spider Assistant**” of the software installation DVD
- Select the language for the installation procedure
- Read the software installation instruction and click “**Next**”
- Accept the license agreement clicking on “**Yes**”
- Specify the directory for the Spider 8 Assistant software and click on “**Next**”
- Click “**Next**” for starting with the installation
- Wait the end of the installation process
- Re-start the system at the end of the installation procedure



WARNING:

If you use Windows 7 (or higher) as OS, we suggest to “Run as Administrator” the file “**Setup.exe**” in the folder “**06_Spider Assistant**” of the software installation DVD.

- Click on “Install Spider 8 Driver” in the main installation folder



WARNING:

If you use Windows 7 (or higher) as OS, we suggest to “Run as Administrator” the file “**NT_IODRV.exe**” in the folder “**07_Spider Driver**” of the software installation DVD.

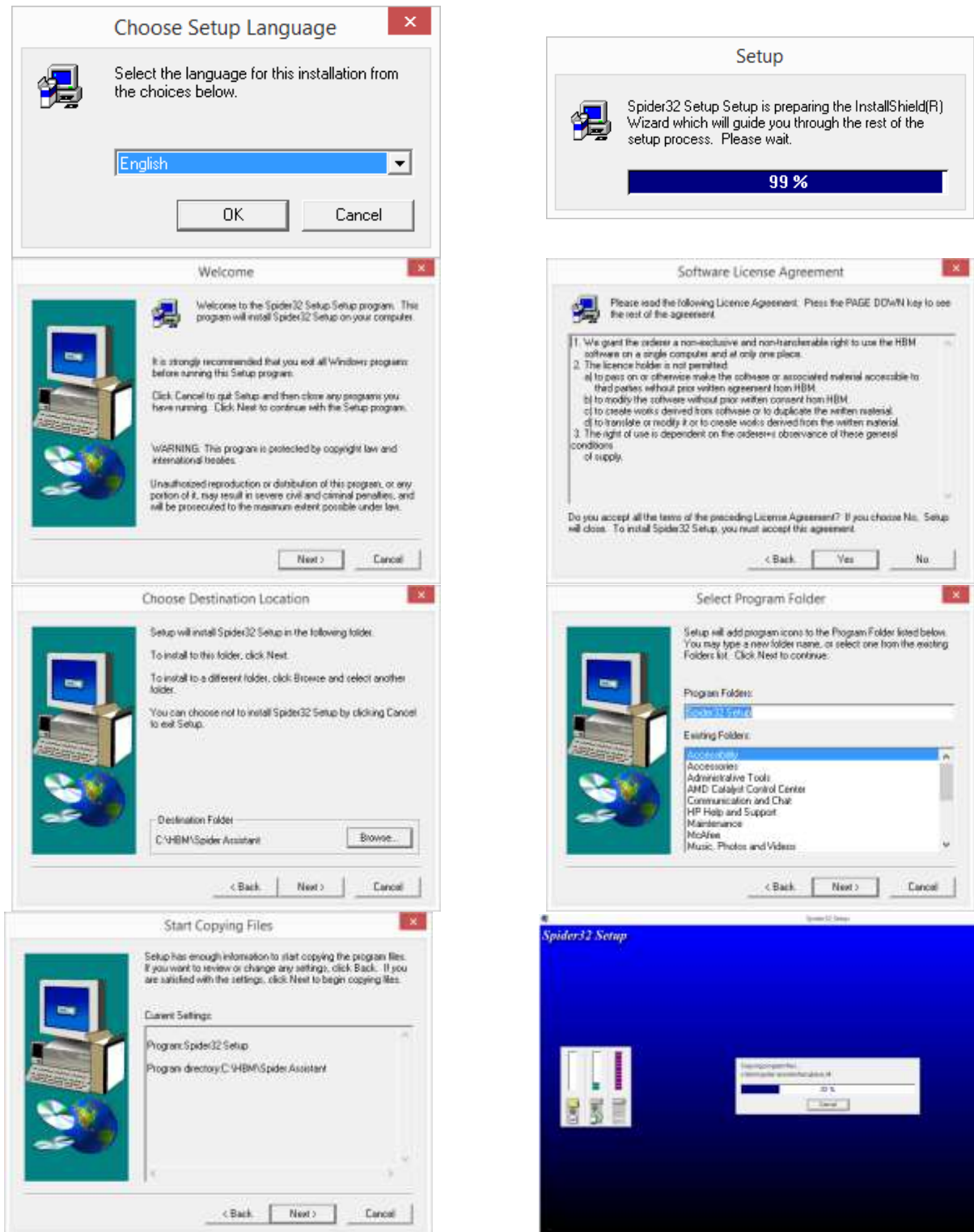


Fig. 3.9 – Installation of Spider 8 assistant software and driver

3.2.9. Install Quantum X Assistant

For the installation of the QuantumX Assistant the following steps has to be performed:

- Click on the file “**Setup.exe**” in the folder “**08_QuantumX**” of the software installation DVD
- Select “**Device assistants, tools, etc.**”
- Close other application and click on “**Next**”
- Accept the license agreement clicking on “**Next**”
- Specify the directory for the QuantumX Assistant software and click on “**Next**”
- Select the “**MX Assistant 4**” and click on “**Next**”
- Click “**Install**” for starting with the installation process
- Wait the end of the installation process
- Close the installation window clicking on “**Finish**”.



WARNING:

If you use Windows 7 (or higher) as OS, we suggest to “Run as Administrator” the file “**Setup.exe**” in the folder “**08_QuantumX**” of the software installation DVD.

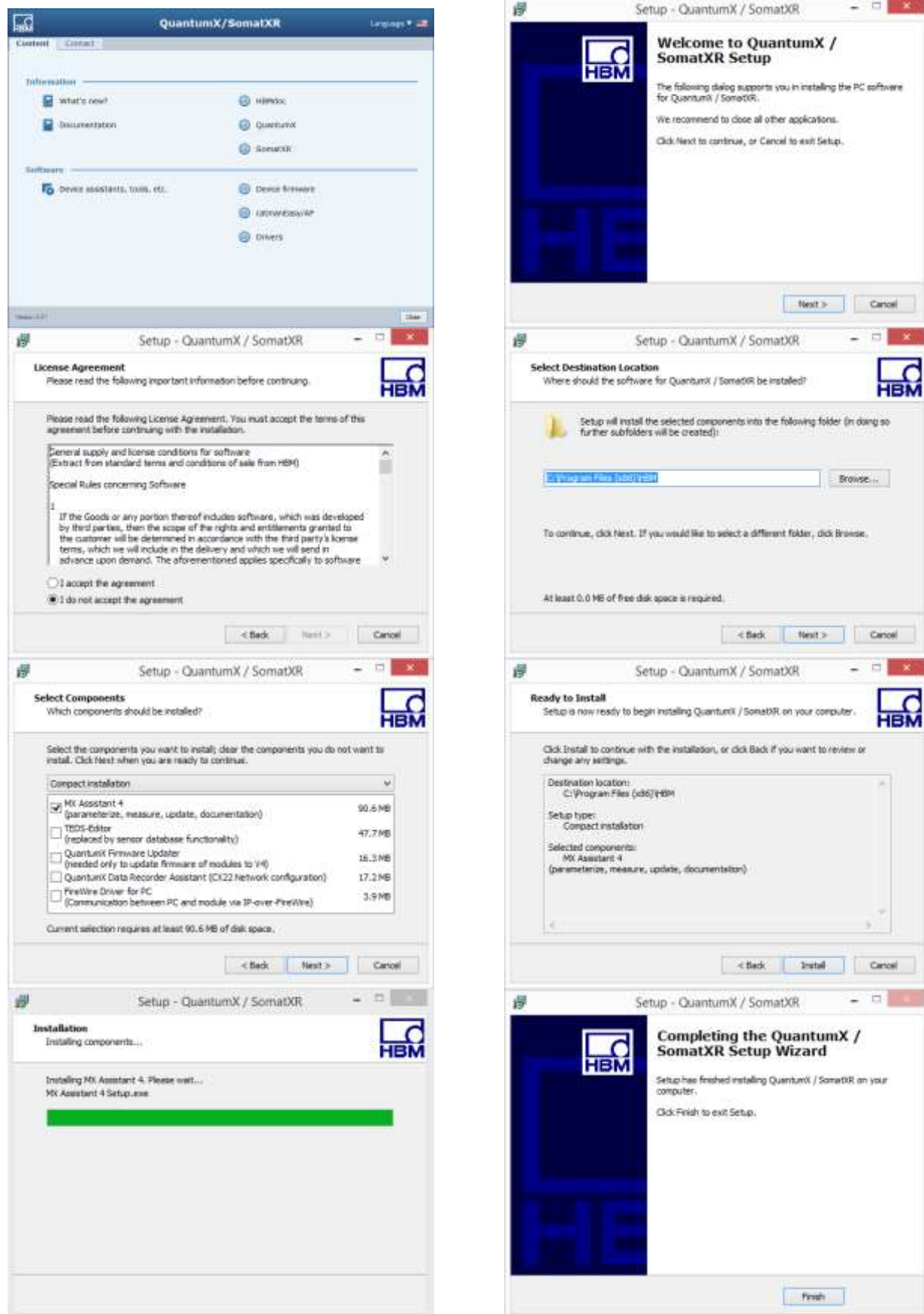


Fig. 3.10 – Installation of QuantumX assistant software

3.2.10. Install Espresso DAQ Assistant

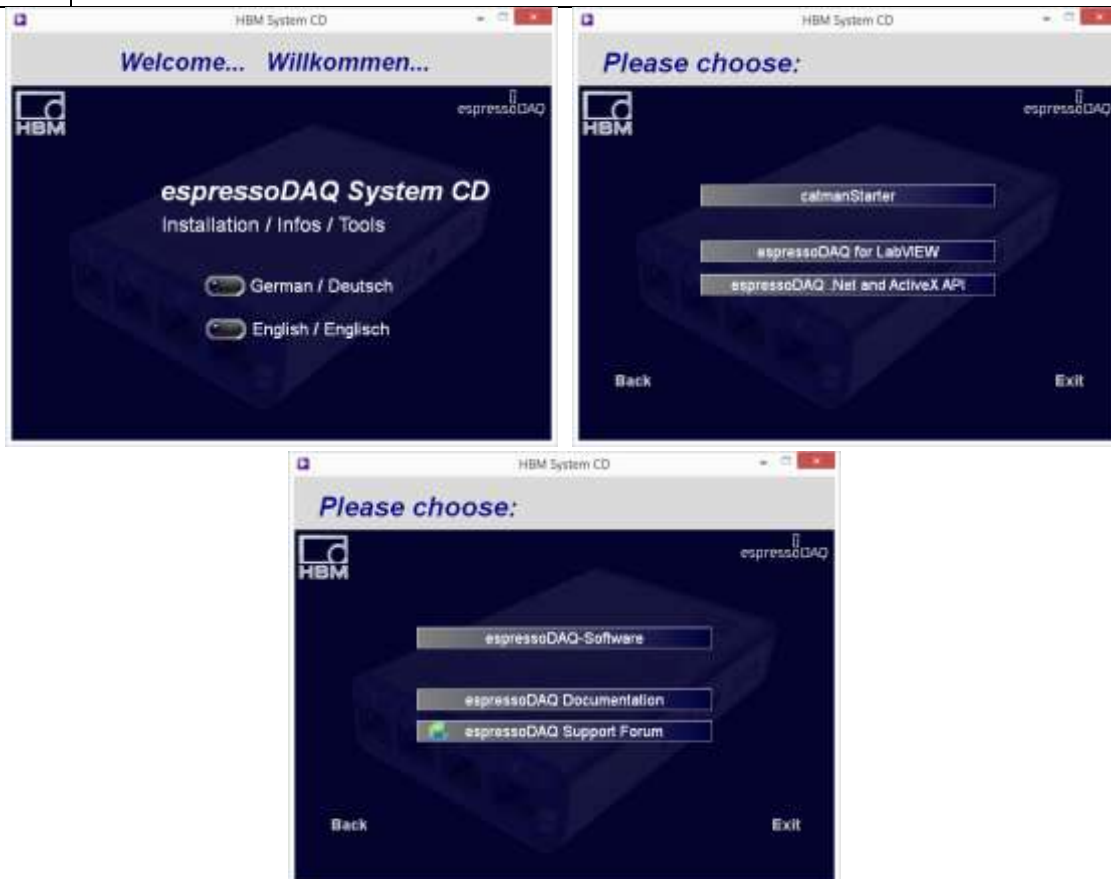
For the installation of the Espresso DAQ Assistant the following steps has to be performed:

- Click on the file “**Setup.exe**” in the folder “**09_EspressoDAQ**” of the software installation DVD
- Select the language, click on “**Espresso DAQ software**” and then on “**Catman Starter**”
- Close other applications and click on “**Next**”
- Accept the license agreement clicking on “**Next**”
- Specify the directory for the QuantumX Assistant software and click on “**Next**”
- Click “**Install**” for starting with the installation
- Wait the end of the installation process
- Close the installation windows clicking on “**Finish**”.
- At the end of the process, click on “**Install**” for the installation of the USB driver.



WARNING:

If you use Windows 7 (or higher) as OS, we suggest to “Run as Administrator” the file “**Setup.exe**” in the folder “**09_EspressoDAQ**” of the software installation DVD.



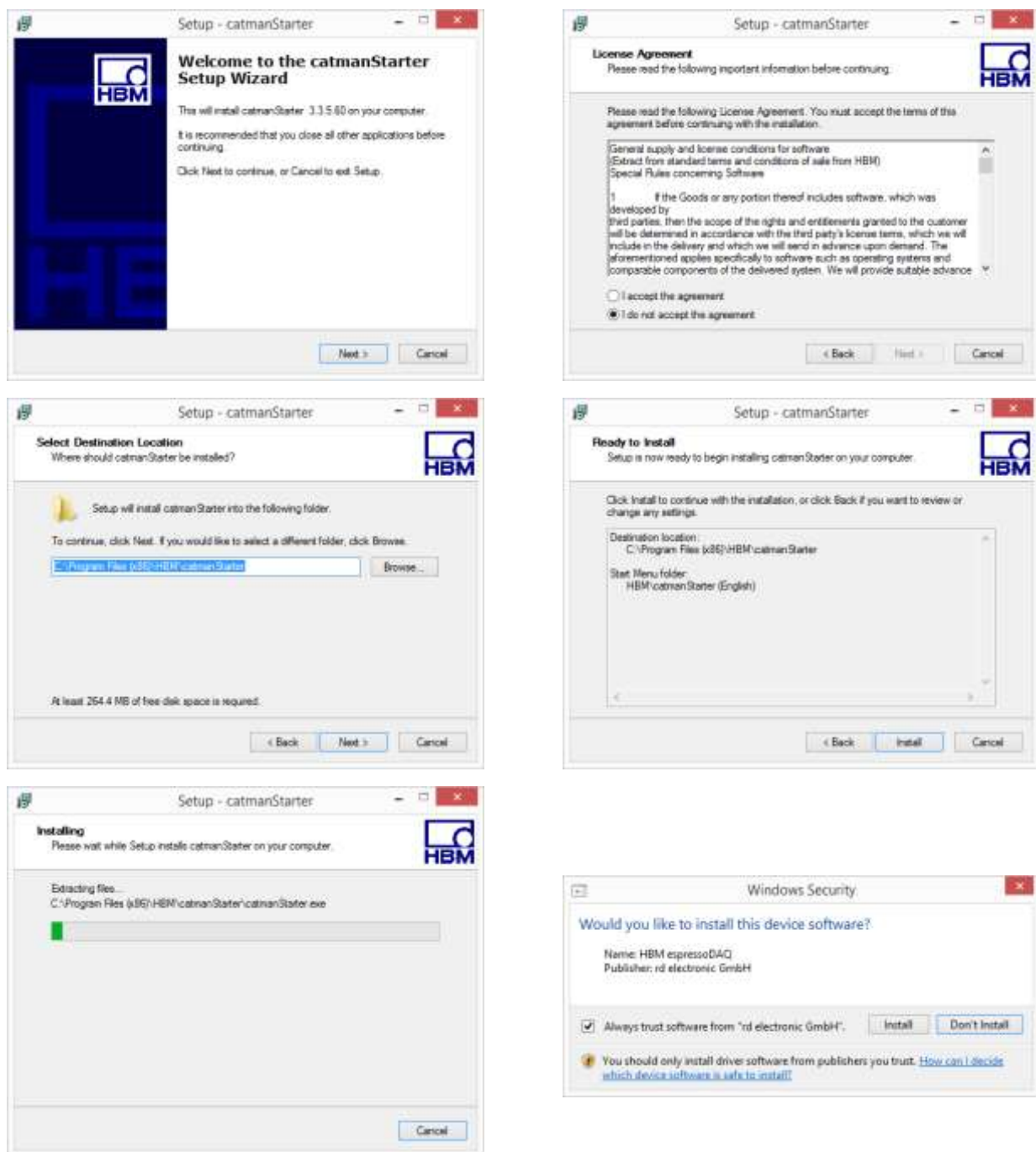


Fig. 3.11 – Installation of Espresso DAQ assistant software

3.2.11. Selection of the COM port and initializing the RSM software

These operations have to be carried out before putting the system in operation and whenever the PC is replaced with another machine.

The “**Installer.exe**” program creates the EVAL and the RSM directories on hard disk C in the folder “**C:\Program Files (x86)**”, where all the system’s programs (RSM.exe and EVAL.exe) and the related management subprograms are installed.

The program can be started from the Windows system menu “**Start**” under the group “**Sint Technology**”.

After the USB to Serial Converters are connected to the PC, the user has to set the correct number for the COM port.

An outline of the operations to be carried out for the COM Port setting is provided in the following procedure.

- Run “**Control panel – System – Hardware - Device Manager**”
- Select “**Port COM**”
- Select the Electronic device port (COM1, COM2 and so on)
- Select “**Port setting - Advanced**”
- Select COM1 as port number
- Repeat the last five steps (if necessary) for HBM Spider 8.30 and select COM2 as port number

When the management software (RSM) is started for the first time, you are asked to key in the screw pitch (Screw Pitch [mm/r]) indicated in the calibration certificate (MOD 07 26 Calibration Certificate).

You are advised to always enter the value at this point. If it is not entered, the software assigns a theoretical reference value, which may always be changed by the relevant procedure (Section 4.10).



WARNING:

If you use Windows 7 (or higher) as OS, you need to “Run as Administrator” the file “**RSM.exe**”.

An outline of the operations to be carried out for installation of the hardware is provided in the following procedure, referring to the diagrams in Fig. 1.1 and following figures.

- Connect the mechanical-optical system to the electronic control system with the Stepper Motor lead.
- Connect the electronic control system to the mains (**Part n° 1**, Fig. 1.6 - Section 1.4).

	<u>WARNING:</u> To reduce the risk of electrical shock to the minimum, use only grounded power cables. The measurement system has been designed to operate correctly in a voltage range between 90 and 264 Vac. Outside this range, the system could be affected or cause damage. Always make sure that the power supply voltage meets the manufacturer's prescriptions.
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- Connect the electronic control system to the PC by the serial cable (RS-232) or USB (**Part n° 5**, Fig. 1.6 - Section 1.4).
- For systems with a compressed air turbine (standard system and orbital system), connect the compressed air tube to the rear of the electronic control unit (compressed air INPUT, **Part n° 2**, Fig. 1.6 - Section 1.4) and connect the turbine power lead between the electronic control unit and the mechanical-optical system (compressed air OUTPUT, **Part n° 2**, Fig. 1.6 - Section 1.4 and **Part n° 5**, Fig. 1.3 - Section 1.3). Leave the compressed air tap closed (Fig. 1.1). All the connections on the system are fast connections and are used along with the connection piping provided with the system.

	<u>WARNING:</u> The inlet air pressure to the electronic control system should not exceed 6 bar (it can be regulated by the reducer mounted above the pressure gauge). The operating pressure of the compressed air turbine should be between 3.5 and 5 bars during hole drilling (it can be checked on the pressure gauge fitted on the electronic control unit). The inlet air pressure varies in relation to the operating conditions, hardness of the material and travel speed, which lower the pressure as the mill operates in harder hole-drilling conditions.
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For electric motor systems, connect the motor cable to the socket on the rear of the electronic control unit (Electric Motor connector, **Part n° 4**, Fig. 1.6 - Section 1.4).

- Connect the electronic device to the power supply by the power switch (**Part n° 1**, Fig. 1.6 - Section 1.4) and put it on with the power button (Part n° 2, Fig. 1.5 - Section 1.4).
- Fit the hardware key in the PC port.
- Open the compressed air tap (for systems with a compressed air turbine).
- The system is ready for use. Start the RSM software for controlling the test procedures and EVAL for data processing.

3.3. *Operating and Maintenance*

**WARNING:**

Operators shall only perform the operations and maintenance procedures described in this manual.

SINT Technology shall not be held liable, either directly or indirectly, for any damage to people or property, including the RESTAN system, caused by operations that do not conform to the instructions and procedures provided in this manual. SINT Technology shall be entitled to judge whether operations are carried out correctly as described herein.

For any further information, please contact SINT Technology technical support team (support@sinttechnology.com).

**WARNING:**

Maintenance and replacement of parts, and any operations related to use of this system must be done by trained technicians of proven experience. Should any particular, non-routine services be required, SINT Technology technical support team (support@sinttechnology.com) should be contacted.

**WARNING:**

Before performing the maintenance operations, please switch off the air compressed (except if request by the operation).

The maintenance operations that may be carried out on the system by operators are the following:

- Changing the fuses on the electronic control system
- Setting the electronic control system hardware
- Changing the compressed air turbine
- Lubricating the compressed air turbine
- Cleaning the microscope lens
- Changing the end mill of the compressed air turbine
- Changing the chuck of the compressed air turbine
- Attaching the micrometers
- Adjusting the gib's plays
- Calibrating the optical unit.

3.3.1. Changing the fuses

There are three fuses on the electronic control system providing protection from any overvoltage spikes on the power supply line and from any electric motor or orbital system failures that would affect their integrity.

The fuses are:

- **T1A, 250V**. Passive protection of the electronic control system (**Part n° 1**, Fig. 1.6 - Section 1.4).
- **T1A, 250V**. Passive protection of the electric motor (Electric Motor, **Part n° 4**, Fig. 1.6 - Section 1.4).
- **T500mA, 250V**. Passive protection of the orbital system electric motor (Orbital Device, **Part n° 4**, Fig. 1.6 - Section 1.4).

In all three cases the fuses should be changed as described in the following procedure:

- Switch off the electronic control system (switch **Part n° 1**, Fig. 1.6 - Section 1.4).
- Disconnect the electronic control system from the mains taking out the power cable.
- Take off the fuse holder lid.
- Check the fuse (using a digital tester, if necessary) and change if damaged.
- Reinststate the operating conditions of the electronic control system putting the fuse holder lid back in place and re-connecting the power lead.



WARNING:

Never open the electronic control system or put any material through the ventilation grilles in the rear cover which could affect operation.

3.3.2. Setting the electronic control system hardware

The electronic control system hardware may be set as follows:

- Switch off the electronic control system (switch **Part n° 1**, Fig. 1.6 - Section 1.4).
- Disconnect the electronic control system from the mains taking out the power cable.
- Remove the transparent protective cover (**Part n° 4**, Fig. 1.6 - Section 1.4).
- Set the hardware
 - Red and brown switch to the right (normally-closed limit switch, green light); red and brown switch to the left (normally-open limit switch, red light).
 - Orange switch to the right (limit switch on the mechanical-optical system); orange switch to the left (limit switch on the electronic control system).
 - Yellow switch to the right (orbital system disabled); yellow switch to the left (orbital system enabled).
- Close the protective cover and re-connect the power cable.



Fig. 3.12 – Hardware switches configuration.



WARNING:

The electronic control system is pre-configured.

Do not realize any modification in the hardware switch setting without the authorization of SINT Technology: it could expose the system or operator to risks.

3.3.3. Changing the compressed air turbine

The turbine may need to be changed when it shows signs of malfunctioning.

To change the turbine, proceed as follows:

- Disconnect the compressed air tube from the compressed air connection (**Part n° 5**, Fig. 1.4, Section 1.3).
- Turn the release button (**Part n° 4**, Fig. 1.4, Section 1.3) about 45°.
- Take out the three screws and remove the rear cover (Fig. 3.15 and Fig. 3.16) with a screwdriver.
- Take out the turbine, pushing it upwards from below (Fig. 3.17).
- Fit the new turbine right into where it is lodged, making sure that the reference mark on the turbine matches the one on the turbine casing.
- Close the rear cover again, tightening the three screws removed at step 3.
- Calibrate the mechanical-optical system (Section 3.3.10).



Material needed for changing the compressed air turbine (**1-SINTT**):

- Spare compressed air turbine (**1-SINTT**)
- Screwdriver

Fig. 3.13 - Material needed for changing compressed air turbine (**1-SINTT**)



Fig. 3.14 - Rotate the air turbine support



Fig. 3.15 - Remove the screw



Fig. 3.16 - Remove the cap of the air turbine support

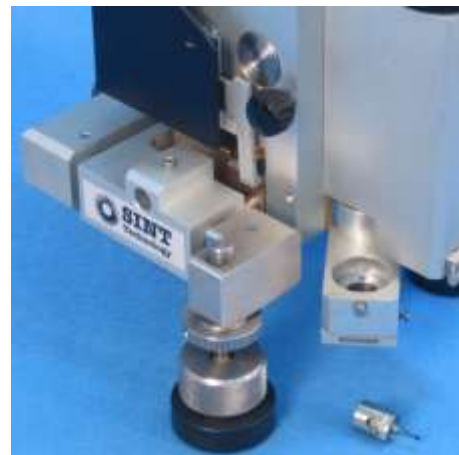


Fig. 3.17 - Remove the air turbine (1-SINTT)

**WARNING:**

Never set the compressed air turbine in operation without fitting a tool.

**WARNING:**

A compressor specifically for use with the Restan system is to be preferred to prevent any damage to the turbine. Use an air filter, remove any particles of moisture from the line and check that the pressure matches the values prescribed in this manual throughout the drilling process.

3.3.4. Lubricating the compressed air turbine

The turbine may need to be lubricated every 2 or 3 drilled holes.



NOTE:

The lubrication of the upper bearing will increase the lifetime of the air turbine. Do not forget to lubricate the air turbine.

To change the turbine, proceed as follows:

- Disconnect the compressed air tube from the compressed air connection (**Part n° 5**, Fig. 1.4, Section 1.3).
- Turn the release button (**Part n° 4**, Fig. 1.4, Section 1.3) about 45° (Fig. 3.19).
- Remove the support's protective cover to access to the back of the turbine (Fig. 3.20).
- Using the lubrication oil provided with the air turbine, add 1-2 drops of lubricant in the area of the support's protective cover (Fig. 3.21).
- Rotate by hand the drill, so that the oil will lubricate the bearing completely (Fig. 3.22).
- Screw down the screw in the center of the support cover (inverting the step described under point 3).
- Turn the support back to the working position, and open the compressed air tap.



Material needed for lubricating the compressed air turbine (**1-SINTT**):

- Lubrication oil for air turbine (**1-SINT OIL**)
- Screwdriver

Fig. 3.18 - Material needed for lubricating the compressed air turbine (**1-SINTT**)



Fig. 3.19 - Rotating the air turbine support



Fig. 3.20 - Removing the screw



Fig. 3.21 – Lubrication of the air turbine

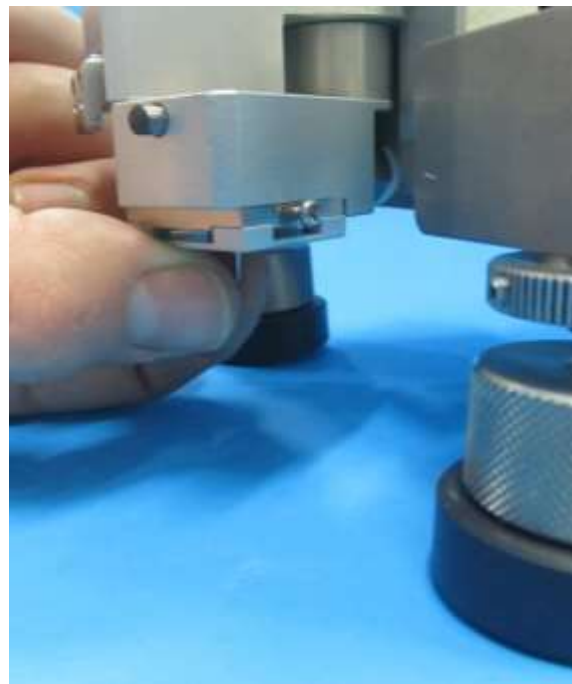


Fig. 3.22 – Rotation of the endmill

**WARNING:**

At the end of the lubrication procedure, remember to re-screw the protective support cover. If forgotten, the lubrication oil and the metal dust could stain the lower lens of the microscope and reduce the quality of the view.

3.3.5. Cleaning the microscope lens

During the normal use of the MTS3000-Restan system, dust and oil could stain the lower lens of the microscope and reduce the quality of the view: in this case a cleaning of the lens can resolve the problem.



Material needed for cleaning the microscope lens:

- Cotton swabs (not included with the system)

Fig. 3.23 - Material needed for cleaning the microscope lens

To clean the microscope lens, proceed as follows:

- Disconnect the compressed air tube from the compressed air connection (**Part n° 5**, Fig. 1.4, Section 1.3).
- Turn the release button (Part n° 4, Fig. 1.4, Section 1.3) about 45° (Fig. 3.24).
- Rotate in orizzontal position the mechanical device of the system.
- Using cotton swabs, remove oil and dust placed on the surface of the lower lens of the microscope. If necessary, moisture the cotton swaps with isopropilic alcohol (Fig. 3.25).
- Verifiy the cleaning of the lens using the microscope: if not clean, repeat the step above.
- Turn the support back to the working position, re-connect the air turbine to the compressed air connection and open the compressed air tap.

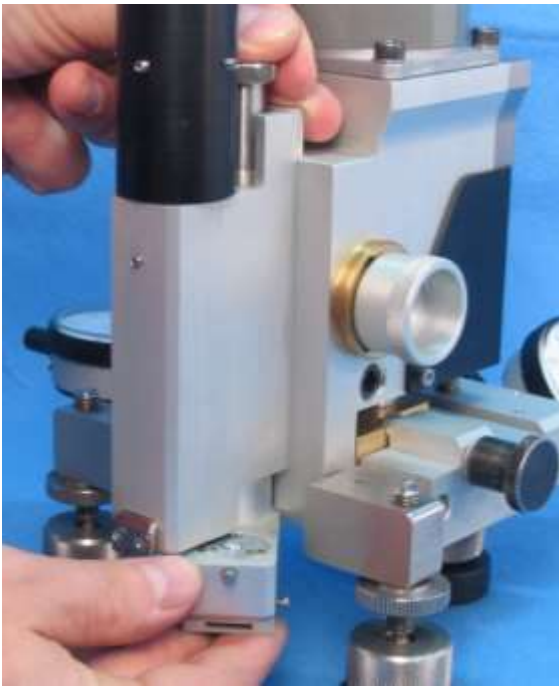


Fig. 3.24 - Rotating the air turbine support



Fig. 3.25 – Cleaning of the lens



WARNING:

During the cleaning of the lower lens, do not use any other tool (except the cotton swabs) that can scratch the surface of the microscope lens.



WARNING:

During the cleaning of the lower lens, do not use any other chemical substance (except the isopropilic alcohol) that can left halos on the surface of the microscope lens.

3.3.6. Changing the end mill of the compressed air turbine

The end mill needs to be changed during some maintenance operations (calibrating the optical unit – Section 3.3.10), or for carrying out a test.

**NOTE:**

SINT Technology suggests to change the drill after every hole-drilling operation, always before positioning the tool.

If the hardness of the material that has to be drilled is not high, the same drill can be used for more than one test.

**WARNING:**

The drill must be changed only when the turbine is static (compressed air system cut off) and the mechanical-optical system is not moving.

Never start the turbine during this procedure.



Material needed for changing the end mill (**1-SINTCT/1**, **1-SINTCTT/1**, **1-SINTD** or **1-SINTCTC**) on the compressed air turbine:

- Special open-end wrench
- End mill, inverted truncated cone-shaped
- Set-screw wrench, $\frac{1}{20}$ "
- Screwdriver.

Fig. 3.26 - Material needed for changing the end mill (**1-SINTCT/1**, **1-SINTCTT/1**, **1-SINTD** or **1-SINTCTC**)

To change the end mill, proceed as follows:

- Close the compressed air tap upstream from the air pressure reducer (Fig. 1.1).

- Turn the turbine support pressing the release button, making sure the slide is locked (Fig. 3.27 - Rotating the air turbine support).
- Unscrew the support's protective cover to access the spindle from the back of the turbine (Fig. 3.28 - Removing the screw).



Fig. 3.27 - Rotating the air turbine support



Fig. 3.28 - Removing the screw

- Holding the shaft still with the special wrench, unscrew the spindle with the 1/20" set-screw wrench (Fig. 3.29 - Unscrewing the chuck).
- Insert the new drill in the spindle and push it to the top (Fig. 3.29).
- Hold the shaft still with the special wrench and re-screw the spindle with the 1/20" set-screw wrench (inverting the step described under point 4).



Fig. 3.29 - Unscrewing the chuck



Fig. 3.30 - Removing the end-mill

- Screw down the screw in the center of the support cover (inverting the step described under point 3).
- Turn the support back to the working position, and open the compressed air tap.

**WARNING:**

The correct tightening of the endmill is very important: if the drill is too loose, the hole depth will be wrong (too deep hole); if, on the contrary, the drill is too tight, the chuck of the turbine will get damaged quickly.

**NOTE:**

During the first changes of the endmill of the MTS3000-Restan, at the end of the operation listed above a verification of the tightening of the endmill is suggested.

For making this operation we suggest to approach manually a surface and activate the drilling process (without advancing): if the tightening is not correct, the drill starts to falling down slowly.

In this case we suggest to repeat the procedure listed above and increasing a little bit the torque applied to the endmill.

**WARNING:**

If the protective cover on the turbine support is not correctly and completely screwed back down, it could unscrew and damage the target.

If the protective cover is not put back and tightened after changing the end mill, dirt would build up on the microscope lens.

**NOTE:**

The selection of the most suitable drill can be done depending on the hardness of the tested material: Fig. 3.12 will provide a preliminary base guide line for the optimal selection.

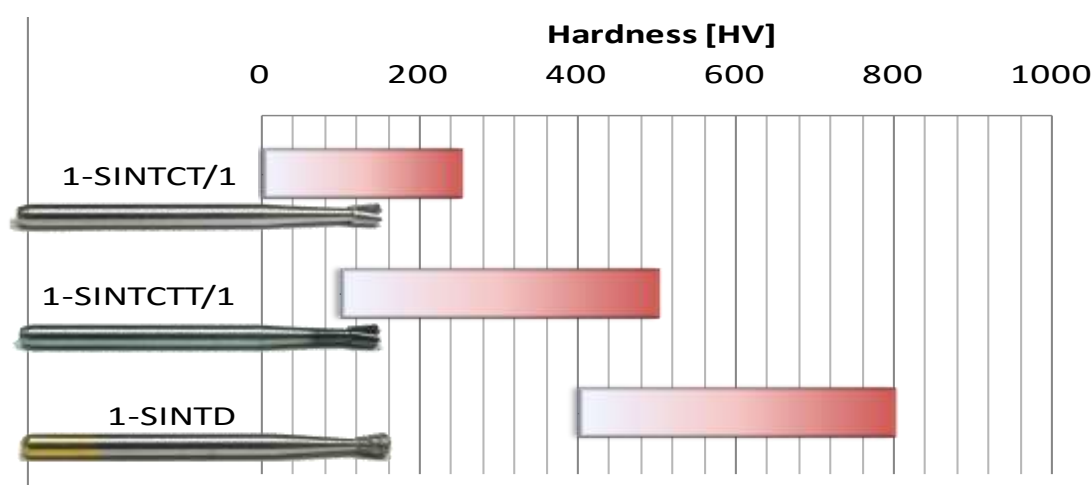


Fig. 3.31 – Different type of end-mill.

3.3.7. Changing the chuck of the compressed air turbine

During the uses of the air turbine sometimes the upper hexagonal part of the chuck could be worn by the $\frac{1}{20}$ " Allen wrench: in this case, it's possible to substitute only the chuck.

**WARNING:**

If the wear starts damaging the hexagonal part of the chuck, we suggest immediately to change it: if the chuck will be too worn, it will be impossible to remove it and the complete air turbine will need to be changed.



Material needed for changing the end mill (**1-SINTC/1**) on the compressed air turbine:

- Special open-end wrench
- Chuck
- Set-screw wrench, $\frac{1}{20}$ "
- Screwdriver.

Fig. 3.32 - Material needed for changing the chuck (**1-SINTC/1**)

To change the chuck, proceed as follows:

- Close the compressed air tap upstream from the air pressure reducer (Fig. 1.1).
- Turn the turbine support pressing the release button, making sure the slide is locked (Fig. 3.33).
- Unscrew the support's protective cover to access the spindle from the back of the turbine (Fig. 3.34).



Fig. 3.33 - Rotating the air turbine support



Fig. 3.34 - Removing the screw

- Holding the shaft still with the special wrench, unscrew completely the spindle with the 1/20" set-screw wrench (Fig. 3.35) and remove the chuck plus the endmill from the upper side.
- Substitute the old chuck and introduce the new one with the endmill in the upper side of the turbine (Fig. 3.36).
- Hold the shaft still with the special wrench and re-screw the spindle with the 1/20" set-screw wrench (inverting the steps described above).



Fig. 3.35 - Unscrewing the chuck



Fig. 3.36 - Removing the end-mill

- Screw down the screw in the center of the support cover (inverting the step described under point 3).
- Turn the support back to the working position, and open the compressed air tap.

3.3.8. Attaching the micrometers

The micrometers give a reading of travel along the X-Y axes required for calculating the size of the hole (Section 0). They are easy to fit on the mechanical-optical system but some special attention is required.



Material needed for attaching the micrometers:

- Micrometers
- 2mm set-screw wrench.

Fig. 3.37 - Material needed for attaching the micrometers

- Unscrew the 2mm set-screws (**Part n° 22**, Fig. 1.3 and **Part n° 25**, Fig. 1.2 - Section 1.3) until the dial gauge's holes is completely free (Fig. 3.38)
- With the horizontal adjustments (**Part n° 14**, Fig. 1.2 and Fig. 1.3 - Section 1.3), set the mechanical-optical system slide so that it is approximately in the center of the travel distance in both direction X and Y (Fig. 3.39).



NOTE:

It is good practice to put the slide back in the same central position at the end of every reading so that there is always the maximum travel for reading the hole dimensions.



Fig. 3.38 - Unscrewing the dowels



Fig. 3.39 - Adjusting the system in the center

- Insert the micrometer dial gauges (**Part n° 18** and **Part n° 19**, Fig. 1.2 - Section 1.3) sliding them in until the contact point touches the copper base and position the pointer about the middle of the graduated dial (Fig. 3.40).
- Re-screw the set-screws holding the dial gauges (Fig. 3.41). This should not prevent the contact point from moving smoothly and continuously. Check that the tightening is correct by moving the slide to show any blocking or catching of the pointer along the whole travel length.

**WARNING:**

Be carefull at the tightening ot the blocking dowels: if tightened too hard, free movement of the contact point could be affected and the dial gages could be damaged.

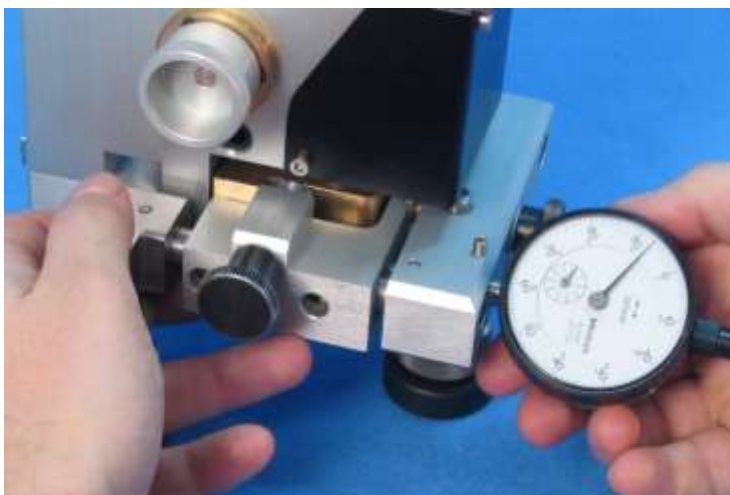


Fig. 3.40 - Insert the micrometer dial gauges



Fig. 3.41 - Re-screwing the dowels

3.3.9. Adjusting of the gib's plays

The gib allows reducing the plays during the translation of the drilling slide: sometimes, due to the normal use of the system (wear) or after a shipping (vibration) the drilling slide starts to increase the plays during the translation. The adjustment of the gib's plays will regulate it as the initial condition.



Material needed for adjusting the gib's plays:

- 1.5mm set-screw wrench.

Fig. 3.42 - Material needed for adjusting the gib's plays

- Put the system in the upper position (Home position)



NOTE:

The lower dowel is accessible using the 1.5mm allen wrench only if the system is placed in the upper position.

- Screw (if the drilling slide is loose) or unscrew (if it's blocked) the upper dowel placed on the right side of the mechanical device of the MTS3000 system near the vertical slide lock (**Part n° 9**, Fig. 1.3 - Section 1.3).
- Repeat the same operation also for the lower dowel.
- Unlock the vertical movement by means of the vertical slide lock (Part n° 9, Fig. 1.3 - Section 1.3) and verify the quality of the translation and the plays (Fig. 3.44).
- Repeat the steps above if the adjustment is not satisfactory (the slide is still too loose or blocked).
- Turn the support back to the working position.



Fig. 3.43 – Regulation of the dowels



Fig. 3.44 – Verifying the gib's plays

**NOTE:**

The optimal regulation of the dowels is a compromise between the quality, the fluidity, the precision and the force needed for obtaining the vertical translation.

The optimal regulation of the gib's plays allows to leave the drilling slide unlocked and fixed (no falling down) and a small torque is requested for obtaining the translation.

**WARNING:**

If the drilling slide is blocked, do not increase the applied torque to the translation knob: it can cause a mechanical failure in the gear transmission.

**WARNING:**

If the drilling slide is too loose, do not leave the drilling slide unlocked: it can falling down and damage the drill, the turbine, the microscope lens and the strain gage rosette.

3.3.10. *Calibrating the optical unit*

One of the fundamental operations to be done to guarantee that a test is conducted correctly is the calibration of the system, which consists in aligning the target in the lens with the drilling axis (represented by the compressed air turbine alone or mounted on the orbital system, or by the electric motor). This procedure should always be carried out in the following circumstances:

- The first time the system is used or whenever it has been transported or shipped (vibration caused by being carried, although minimal, can knock the system out of alignment).
- Whenever the compressed air turbine is changed or the drilling system is changed from the standard to the orbital system, or to the electric motor system.
- Whenever the target center is felt not to be perfectly aligned with the drilling axis (for example, if there is high eccentricity).

The following procedure should be followed to do the calibration:

- Install the drill for centering (**1-SINTCTC**) as previously illustrated (Section 3.3.6).
- Set the system on a flat metal surface so that the drilling axis is at 90° to the metal surface by adjusting the height and angle of the three feet (**Part n° 2**, Fig. 3.46). Use the square to help you do this (**Part n° 1**, Fig. 3.46) checking both orthogonal directions. Lock the foot joints and threaded rods (**Part n° 2** and **Part n° 3**, Fig. 3.46). Using the microscope, make sure that the area around the center of the microscope is not pitted or indented. Set the dial gauges at zero.



Material needed for calibrating the optical unit:

- 1mm set-screw wrench
- 1/20" set-screw wrench
- Open-end wrench
- Alignment end mill (**1-SINTCTC**)
- L-square.

Fig. 3.45 - Material needed for calibrating the optical unit

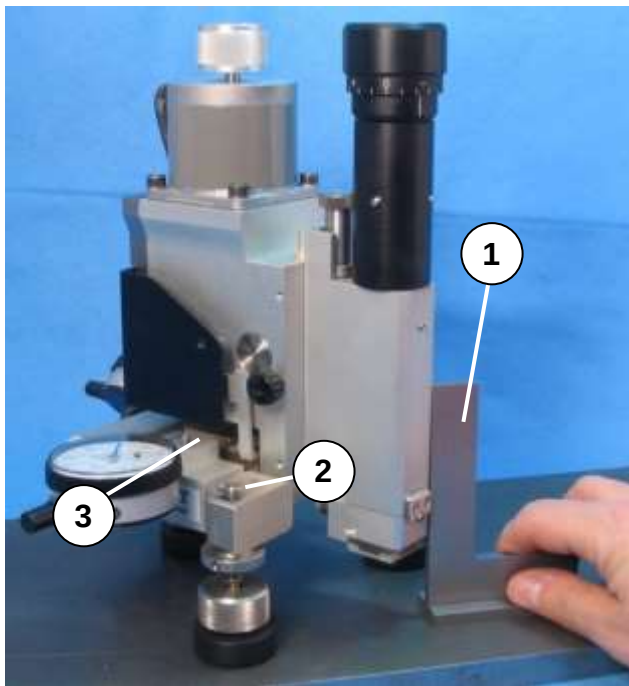


Fig. 3.46 - Adjusting the vertical position



Fig. 3.47 - Adjusting the vertical distance

- Set the system in the Home position, and then lower it by about 0.500 mm from when the upper limit switch is disconnected.
- Turn the vertical adjustment (**Part n° 9**, Fig. 1.3 - Section 1.3) to move the tip of the alignment end mill as close as possible to the metal surface without touching it (Fig. 3.47).
- Lock the vertical movement (Fig. 3.48) by means of the vertical slide lock (**Part n° 9**, Fig. 1.3 - Section 1.3).
- Connect the zero setting cable (BNC side) on the back of the electronic control unit (**Part n° 4**, Fig. 1.6 - Section 1.4) and the 2 alligators clips to the surface of the specimen and to the body of the drilling device (for example, to the screw of **Part n° 26**, Fig. 1.3 - Section 1.3), and activate the procedure for identifying the surface of the specimen (Section 5.8) until the system stops moving.
- Increase the sizes of the conical sign advancing the drill in the material of approximately 0.05mm.
- Lift the slide for vertical movement, releasing the vertical slide lock (**Part n° 16**, Fig. 1.3 - Section 1.3). Turn the turbine support 45° pressing the turbine release (**Part n° 4**, Fig. 1.4 - Section 1.3) to free the view of the microscope (Fig. 3.50) and lock it in position.



Fig. 3.48 - Lock the vertical movement

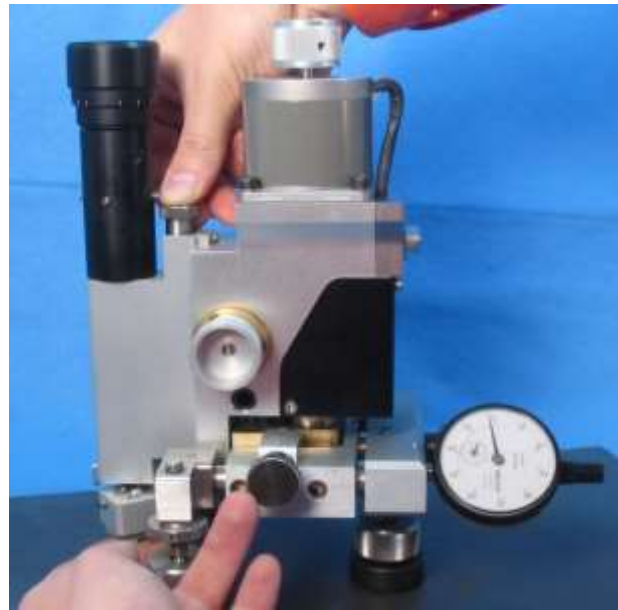


Fig. 3.49 - Inserting the alignment end mill (1-SINTCTC)

- Observe the surface of the specimen through the microscope, and focus on the tip of the indentation until you get a clear, sharp image. To do this, you have to allow the slide to move freely; then, once you have the right position, the slide has to be locked again.
- Turn the ring nut at the top of the microscope until the target in the microscope is focused. This has to be done every time the microscope is used by a different person as it allows correction for the operator's sight for focusing.

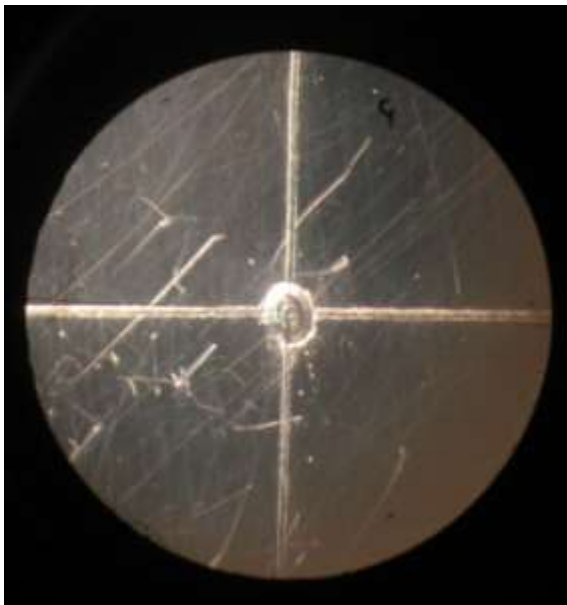


Fig. 3.50 - Checking the sign made by the alignment end mill (1-SINTCTC)



Fig. 3.51 - Aligning the drilling axes and the optical axes

**WARNING:**

Make sure vertical movement is properly locked otherwise the whole vertical slide section would drop, if the turbine release were pressed and the turbine support turned, risking damage.

- Undo the screw (**Part n° 24**, Fig. 1.3 - Section 1.3) with the 1.5 mm set-screw wrench and turn the microscope until the axes of the target align with the X and Y axes of the drilling system. Moving one of the two X and Y axes (**Part n° 14**, Fig. 1.3 - Section 1.3), check that the sign made on the surface moves parallel to the two axes as they are moved. Reset the dial gauges and tighten the screw.
- Adjust the four socket-head screws (**Part n° 21**, Fig. 1.3 - Section 1.3) with the 1.5 mm set-screw wrench to move the center of the lens reticule (Fig. 3.51). To do this, you have to first loosen the two screws nearest the center of the indentation and then, alternately screwing down opposite screws, move the reticule until it is aligned with the center of the indentation that has been made (Fig. 3.50). During this operation it is important not to tighten one screw and then the one next to it as two tightened screws in one direction impede free movement in the orthogonal direction. This would make the screw force on the cylinder holding the target risking marking it, which would make future calibrations difficult, and an alignment error although the system appears to be centered. Finally, gradually tighten the four screws in sequence.
- Check the system is correctly calibrated by going through the procedure from point 3 to point 12. Should it not be correct, repeat points 9 and 10. A well-trained operator can do this operation in two to three times, including checking calibration.

The system is then calibrated and ready for doing a test.

4. DESCRIPTION OF THE SOFTWARE COMMANDS AND ACQUISITION DATA

The following procedures can be selected from the main menu (Fig. 4.1):



Fig. 4.1 - Main menu

- Positioning Control
- Test Setup
- Test Manager
- Default setting
- Restore Interrupted Test
- Exit

These functions are explained in detail below.

The RESTAN software (RSM and EVAL) includes an on-line help function. Simply press **(Ctrl + H)** and click on the key concerned.

4.1. Positioning control

On selecting the Positioning Control pushbutton, the software opens the control window (Fig. 4.2) that allows you to directly control the mechanical-optical system and check the status of connections to the electronic control unit via software.

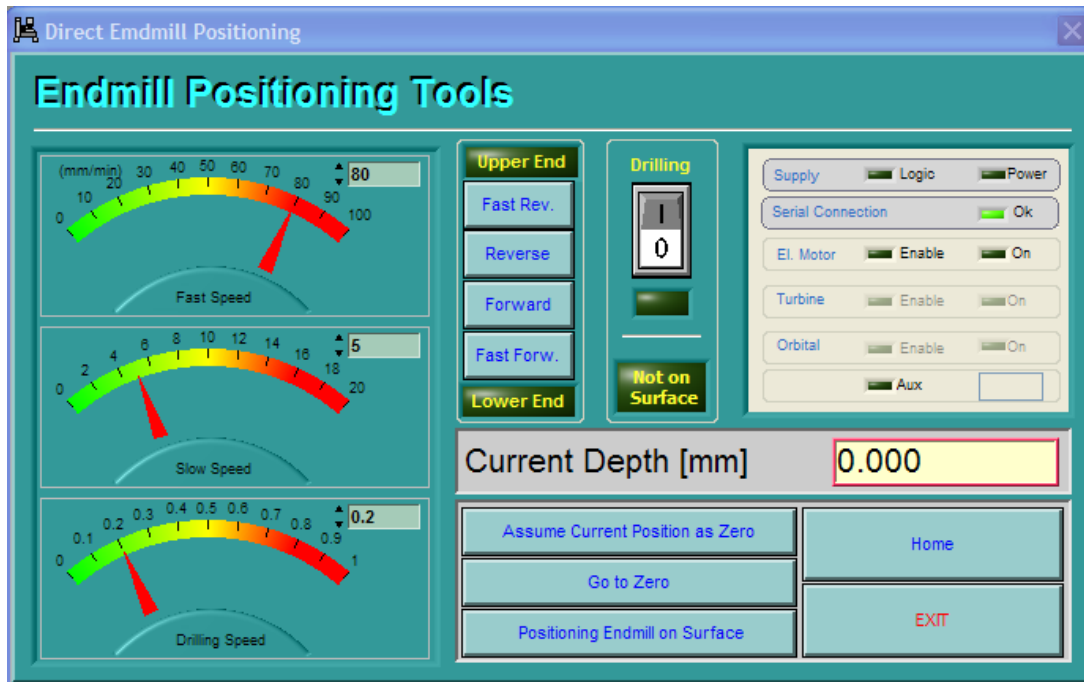


Fig. 4.2 - Positioning Control Window

The control window contains the following options:

- **Fast Speed:** allows you to regulate the electric motor fast speed in mm/min by moving the pointer indicator or putting in the numerical value.
- **Slow Speed:** allows you to regulate the electric motor slow speed in mm/min by moving the pointer indicator or putting in the numerical value.
- **Drilling Speed:** allows you to regulate the electric motor speed in mm/min during performance of a test by moving the pointer indicator or putting in the numerical value. Speeds are usually between 0.1 and 0.25 mm/min.
- **Fast Rev:** quickly raises the mobile unit at the set speed (Fast Speed).
- **Reverse:** slowly raises the mobile unit at the set speed (Slow Speed).
- **Forward:** slowly lowers the mobile unit at the set speed (Slow Speed).
- **Fast For:** quickly lowers the mobile unit at the set speed (Fast Speed).
- **Drilling:** one of the following devices is started depending on the drilling method
 - Turbine
 - Turbine and orbital revolution motion
 - Electric motor

- **Assume Current Position as Zero:** resets the depth indicator (Current Depth [mm]). Zero during testing corresponds to the surface of the specimen.
- **Go to Zero:** effects rapid vertical movement, automatically positioning the end mill at zero (for example, the surface of the material being studied).
- **Positioning Endmill on Surface:** starts the procedure for automatically identifying the zero level (Section 4.2).
- **Home:** effects rapid vertical movement, automatically taking the mobile unit to the uppermost position from which it's possible to drill (just out of the upper limit).
- **EXIT:** allows you to get out of the current window and back to the main menu.

The pilot lights in this window (Fig. 4.2) are:

- **Upper End:** goes on when the mobile unit reaches and stops at the uppermost point.
- **Lower End:** goes on when the mobile unit reaches and stops at the lowermost point.

Fast forward or fast reverse are allowed only from a safe level so if you want to activate either of these from one of the two aforementioned positions, the system will first activate slow movement up to a safe position and then automatically change over to fast movement.

- **Not on Surface:** comes on ("On Surface") only when zero level is reached during the automatic identification procedure (Section 4.2).
- **Supply:** if this light is off, it indicates that the supply for the system's logic (Logic), or power electronics (Power) is not correct. Both lights have to be on for the system to work correctly.
- **Serial Connection:** shows the correct connection between the software and electronics. If it is off, you can try and connect the system by pressing the pilot light.
- **Current Depth [mm]:** shows the current level of the end mill.
- **El. Motor:** shows the electric motor status. *Enable* is on when the electric motor cable is in the connector on the rear of the electronic control unit which automatically disables the compressed air system and the power supply for the orbital motor. *On* is lit up when the electric motor is running.
- **Turbine:** shows the operating status of the turbine. *Enable* is on when the inlet pressure to the electronic control unit is sufficient to guarantee performance of the test. Should the air pressure drop below a set limit (set by the manufacturers), the pilot light automatically goes off, stopping the compressed air turbine from being operated and continuation of testing. *On* is lit up when the compressed air turbine is running and the inlet pressure is sufficient to guarantee the hole drilling.
- **Orbital:** shows the operating status of the orbital system. *Enable* is on when the orbital system electric motor cable is connected. *On* lights up when rotation of the orbital system

is enabled in conjunction with operation of the compressed air turbine, and the supply voltage shown in the indicator below it is between 5.8 and 12 V.

	<u>NOTE:</u> It is possible for the On-LEDs for all three drilling methods: with an electric motor (plugged into the rear of the electronic control unit), by compressed air (sufficient inlet pressure to the electronic control unit) and with the orbital system (orbital motor connected to the mechanical system) to be on at the same time. In this situation, the software enables only the electric motor, contemporaneously disabling the compressed air system. Should all the On lights be on, except for the electric motor one, the system would automatically enable opening of the solenoid valve thus powering the compressed air system and the orbital system electric motor, although it is not fitted on the head of the mechanical-optical system. Always make sure that the mobile head of the orbital system is correctly fitted before starting the turbine.
---	---

4.2. Positioning the end mill on the surface of the specimen

Before drilling a hole, the end mill has to be positioned on the zero point. The zero point is the point of contact between the end mill and the surface of the metal (Section 5.8). The procedure to be followed is described below:

- Click on Positioning Control (Fig. 4.1) to access the relevant window (Fig. 4.2) and select Positioning Endmill on Surface.
- The turbine starts and the end mill moves forward at a speed of 0.3 mm/min. At this stage all manual controls are disabled and only the EMERGENCY STOP can be used to immediately stop the automatic procedure, if necessary.
- When the end mill comes into contact with the surface of the metal, removing a minimum quantity, the system stops and signals the end-of-operation message **“WARNING! The current position will be taken as the reference for hole depth”**. The pilot light in the top corner will go red.

	<u>NOTE:</u> Once the zero level (surface of the material being tested) is identified, any manual vertical movement automatically cancels the reference. It is therefore important to remember that from this point on only vertical movements managed by the program via software are possible.
---	---

If the material to be drilled is not metal, only manual positioning can be done using the Forward and Reverse controls.

On reaching the surface, select “Assume Current Position as Zero”. The message **“Do you really want to assume this position as Zero Reference for Hole Depth?”** will appear.

**NOTE:**

During these operations remember to always use a speed no higher than 0.3 mm/min to approach the surface of the material.

4.3. Test setup

This window (Fig. 4.3) allows you to key in all the parameters required for testing. It is split into the following sections:

- Step setting
- Step investigator
- Material type
- Instrument setting
- General data settings
- Strain gauge settings

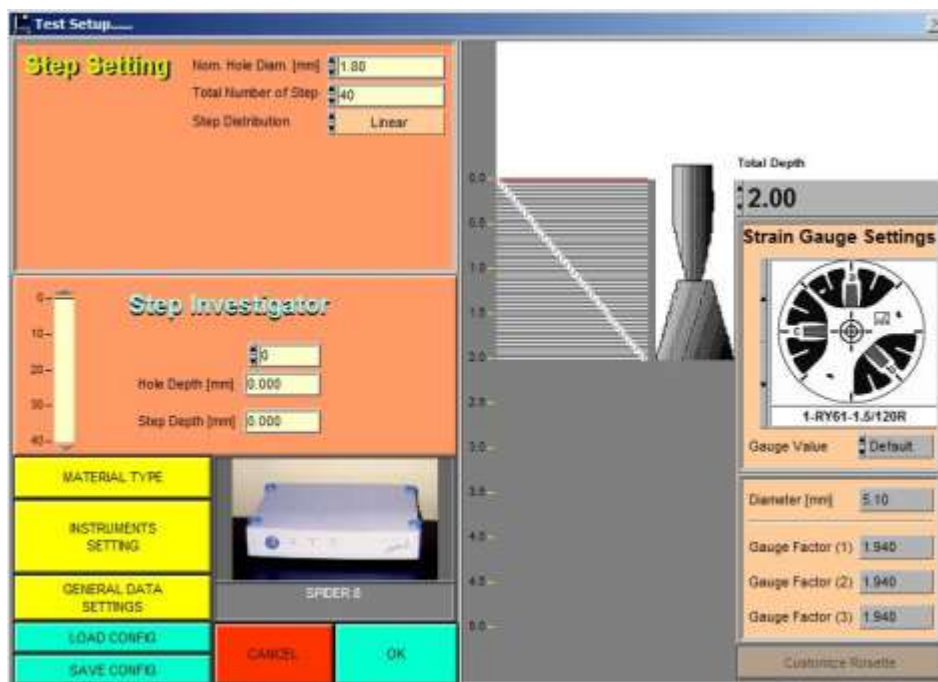


Fig. 4.3 - Test setup window

4.4. Step Setting

The Step Setting section is for entering:

- The nominal hole diameter
- The desired number of drilling steps
- The distribution of the steps (hole profile) to be selected from the following four options:

- **Linear:** every drilling step has the same value (Fig. 4.3).
- **Polynomial:** the penetration dimension of the drilling steps varies polynomially. The order of the polynomial can be modified by the *Tension Factor* horizontal bar which will appear selecting the present option, and which makes it possible to modify the hole profile increasing the number of steps in proximity to the surface of the metal on an increase in the set order.
- **Uniform Groups:** makes it possible to select up to four different intervals in which it is possible to choose a different step. On selecting this option, 3 parameters will appear to be set (Fig. 4.4): n° of Intervals (from 2 to 4), Depth Limits [mm] (depth limit of each interval) and Step Value [mm] (penetration of each interval). The operator shall therefore have to set the number of intervals into which the drilling profile is to be subdivided, and for each of these the operator will have to fix the maximum dimension to apply to the selected penetration step.

Take for example the situation illustrated in Fig. 4.4: the operator has chosen to split the hole into 3 intervals, the first of which goes from zero to 0.1 mm with a drilling interval of 0.01 mm (10 steps). The second interval goes from 0.1 mm to 1 mm with a drilling interval of 0.02 mm (45 steps), and the third interval goes from 1 mm to 2 mm with a drilling interval of 0.11 mm (9 steps). Therefore, to make a 2 mm hole a number of 64 drilling steps have to be set; having selected 75 drilling steps, the final depth reached during the test will be 3.20 mm. So, once the parameters in the Uniform Groups option are set, the total number of steps needs to be changed to obtain the desired hole dimension.

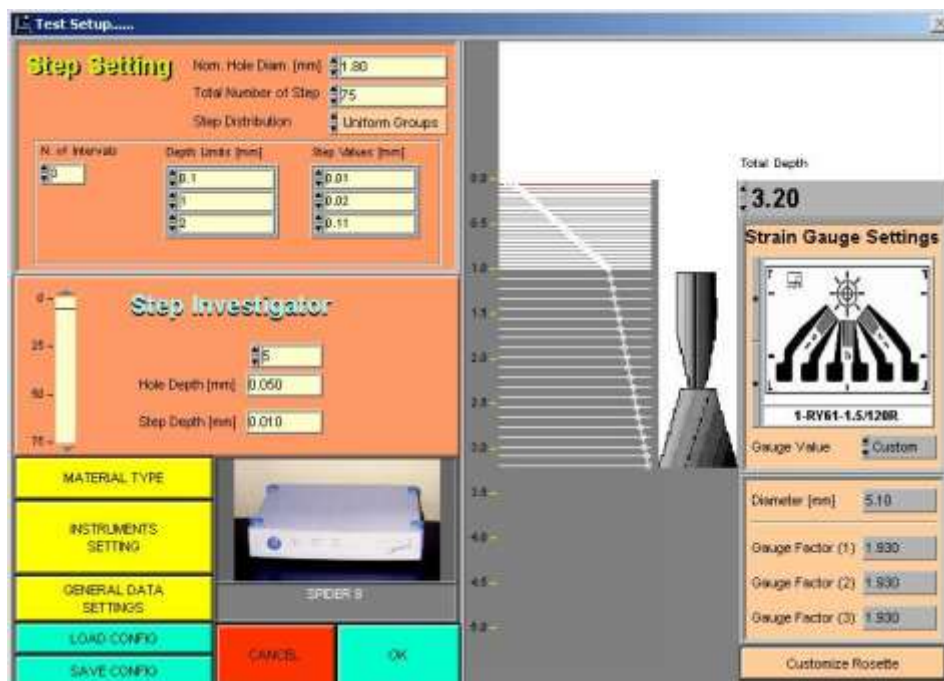


Fig. 4.4 - Test setup window

- **Mixed:** subdivides the penetration depth of the drilling steps into two sections, the first the linear type and the second the polynomial type with an order such as to guarantee the connection between the dimension fixed for the linear section and the final hole dimension.

**NOTE:**

The software allows any step to be set and drilled but if the minimum mechanical resolution guaranteed by the system is exceeded, the software automatically warns the operator as follows: "Warning! Minimum step smaller than mechanical resolution".

Next to the Step Setting window you can see a graphic representation of the selected profile with the related depth the hole will be drilled to during testing. Holes can be drilled to a maximum depth of 5 mm.

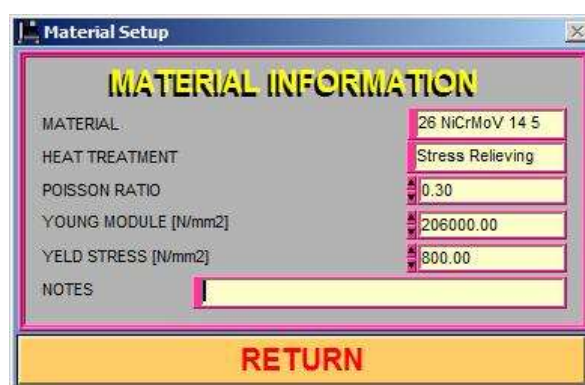
4.5. Step Investigator

This frame (Fig. 4.3 and Fig. 4.4) gives an analysis of the state of the set profile. When the desired number of steps is selected via the scroll bar or relevant indicator, the depth of each step and the hole depth in mm will be shown in the Step Depth and Hole Depth displays and at the same time marked on the graph with a red line.

4.6. Material Type

When the key **MATERIAL TYPE** is selected, a dialog window (**Material Information** - Fig. 4.5) appears for entering the following information:

- **Material:** designation of the material the test specimen or component is made of
- **Heat Treatment:** description of any heat treatment
- **Poisson's Ratio:** Poisson ratio of the material
- **Young's modulus [N/mm²]:** modulus of elasticity of the material
- **Notes:** Space provided for entering more detailed information about the test



MATERIAL INFORMATION	
MATERIAL	26 NiCrMoV 14 5
HEAT TREATMENT	Stress Relieving
POISSON RATIO	0.30
YOUNG MODULE [N/mm ²]	206000.00
YELD STRESS [N/mm ²]	800.00
NOTES	
RETURN	

Fig. 4.5 - Material type window

**NOTE:**

The Poisson's ratio and Young's modulus values entered in this window are the start-entered values used by the EVAL processing software to calculate the stresses.

Press **RETURN** to go back to the **TEST SETUP** window.

4.7. Instrument Setting

When the function **INSTRUMENT SETTING** is pressed, a dialog window opens (**Instrument selection** - Fig. 4.6) allowing you to select the instrument used to acquire the strain gauge signal. This can be done either from a ring list on the left of the window or from a pull-down menu, left-clicking on the figure of the instrument.

Once you have selected the instrument, click on **INSTRUMENT SETTING** to configure it.



Fig. 4.6 - Instrument setting window

Select **OK** to save the settings of the selected instrument and go back to the **TEST SETUP** window, or select **CANCEL** to exit from the instrument selection window without saving any changes.

The instrument that is selected is shown in the image next to the **INSTRUMENT SETTING** function in the **TEST SETUP** window.

The following instruments can be selected:

- HBM Spider8 and Spider 8-30
- HBM MGCPlus
- HBM QuantumX MX440A – MX840A – MX1615
- HBM EspressoDAQ DQ430
- VI Server Data
- PCI 6023E (with an analog strain gauge amplifier - On request)
- DAQCARD 6024E (with an analog strain gauge amplifier - On request)

4.7.1. SPIDER 8 and SPIDER 8-30

For more detailed information on the **SPIDER 8** and **SPIDER 8-30** system, refer to the related HBM manual.

The following parameters have to be specified in the window reserved for setting these instruments (Fig. 4.7):

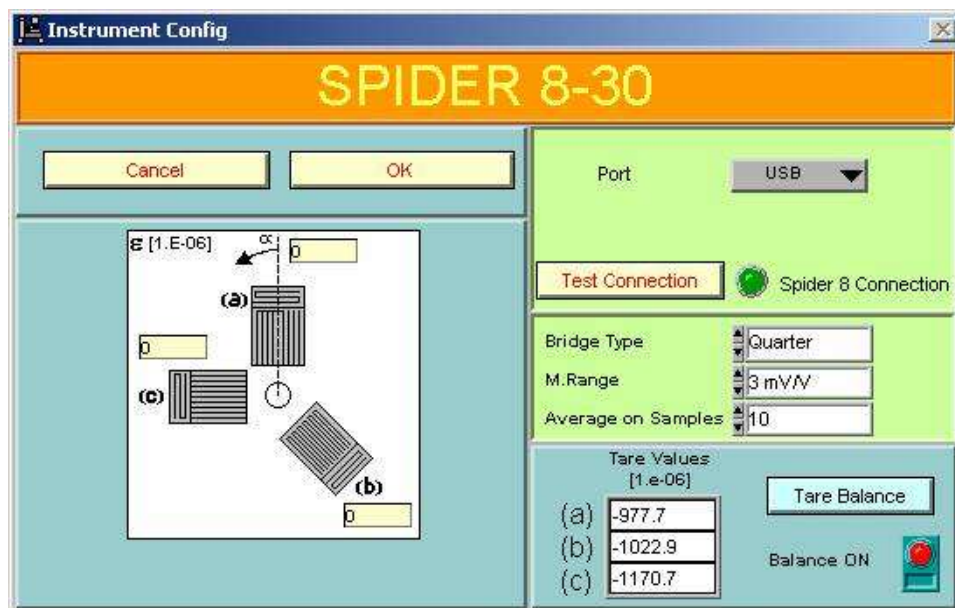


Fig. 4.7 - SPIDER 8 and SPIDER 8-30 configuration panel

- **Port:** allows you to select the port by which SPIDER 8, or SPIDER 8-30, is connected to the software from one of the following:
 - COM 1 ÷ 2
 - LPT 1 ÷ 2
 - USB
- **Test Connection:** allows you to establish or verify the connection between the selected port of communication and the software.
- **Mode:** allows you to select the operating mode of connection to Spider 8 from one of the following:
 - 600
 - 1200
 - 2400
 - 4800
 - 9600
 - 19200
 - 38400
 - 57600
 - 115200
 - NibbleMode
 - Bit8Mode

- ByteMode
- EPPMode
- **Bridge Type:** allows you to select the type of configuration of the strain gauge bridge:
 - Full Bridge
 - Half Bridge
 - Quarter Bridge (only for the 8-30 version).
- **M. Range:** allows you to select the measurement range of the amplifier from one of the following:
 - 3 mV/V
 - 12 mV/V
 - 125 mV/V
 - 500 mV/V
- **Average on Samples:** number of samples (for each grid of the SG at the end of each step) that are read and averaged, from 10 to 50.

The SPIDER 8 / SPIDER 8-30 window also contains the following:

- **Tare Balance:** for balancing the strain gauge bridge reading
- **Balance On/Off:** for putting bridge balancing ON/OFF
- **Tare Values:** shows the numerical index of the current calibration value for each channel
- **Spider 8 Connection:** shows the connection status (green light if connected).



WARNING:

The three strain gauge elements of the rosette - (a), (b), (c) for the CW rosettes or (1), (2), (3) for the CCW rosettes – have to be respectively connected to channels 0, 1 and 2 of Spider 8 and Spider 8-30.

4.7.2. MGCplus

For more detailed information on the MGC, refer to the HBM manual. A dedicated panel (Fig. 4.8) is provided for input of the following parameters:

- **Element connection:** In the first row of the “Element Connection” window (Fig. 4.8), enter the channels on which elements (a),(b),(c) or (1),(2),(3) are connected. There is also an indicator (the second row) for displaying of the message **ERROR** on the channel where an error is detected. If no error is present, the indicator displays the message **OK**.

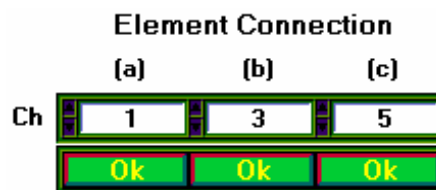


Fig. 4.8 - Element connection

- **Excitation Voltage:** Desired bridge excitation voltage:

- 1V
- 2.5V
- 5V

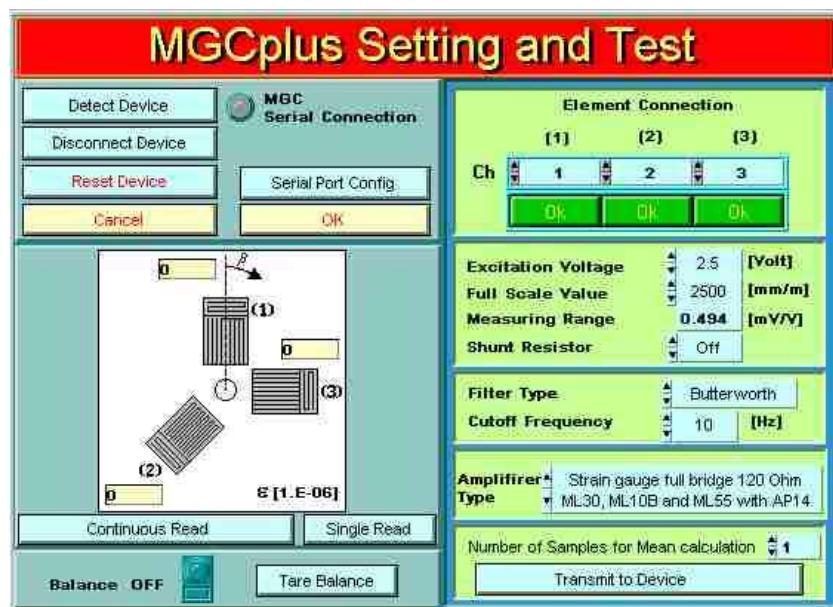


Fig. 4.9 - MGCPlus Control panel

- **Full Scale Value:** Full-scale value without decimal point used for indication.
- **Measuring Range:** Measuring range is adjusted to the value shown on this indicator.
- **Shunt Resistor:** Shunt status ON/OFF. The amplifier is adjusted to the desired transducer configuration.
- **Filter Type:** The type of the low-pass filter can be selected (Bessel or Butterworth)
- **Cutoff Frequency:** the selected filter is adjusted to the cutoff frequency set by this control.
- **Number of samples for Mean calculation:** Number of measured values used for mean calculation.

The HBM-MGC panel contains the following components:

- **Single Read:** Press this button to have a single strain reading.
- **Continuous Read:** Press this button to have continuous strain reading.

- **Tare Balance:** Press this button to set the balance of the strain gage bridge.
- **Balance State:** Switch the balance status ON/OFF.
- **Transmit to device:** set the device with the current parameters
- **Detect Device** and **Disconnect Device:** connect and disconnect the device
- **Serial Port Config:** configure the serial communication LED to show the correct serial connection.

4.7.3. HBM QuantumX MX440A – MX840A – MX1615

For more detailed information on the **QuantumX MX440A**, **QuantumX MX840A** and **MX1615** system, refer to the related HBM manual.

Before starting a test, some basic settings must be loaded into the strain-gauge amplifier Quantum X to allow a correct reading of the strain-gauges. One of these functions is the channels auto-calibration. To turn off this function, open the QuantumX Assistant program.



Fig. 4.10 - Quantum “X” Assistant Icon

Select the IP address of the instrument you are using, choosing it among the available IP addresses, and then click the **OK** button.

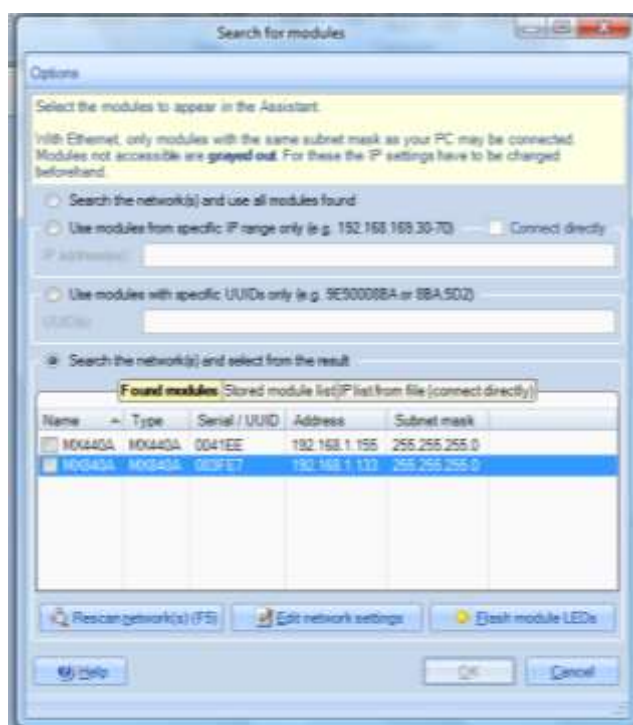


Fig. 4.11 - Amplifier IP choice

Click with the right button of the mouse on an active channel, and select the **Auto-calibration of amplifier** menu.



Fig. 4.12 - Auto-calibration of amplifier electronics Menu

In the section **Requested Settings**, at the voice **Active Calibration Mode**, ensure that the value is set on **Auto-Calibration Disable**. If not, modify this setting (see below).

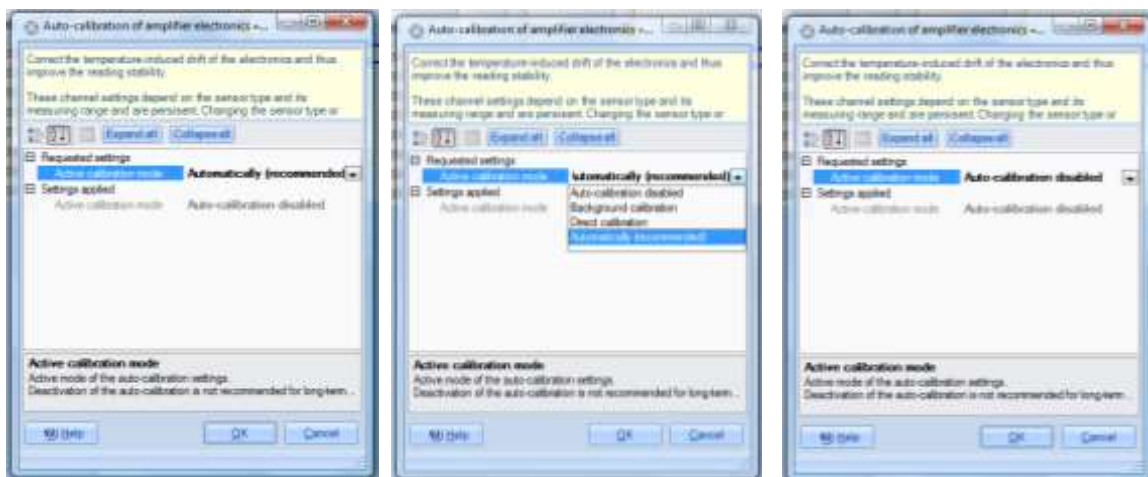


Fig. 4.13 - Auto-calibration turned off

Repeat this operations for each active channel and quit the program.



WARNING:

This operation needs to be performed only the first time you open this program. It's not necessary to do it every time you make a test.

The following parameters have to be specified in the window reserved for setting these instruments:



Fig. 4.14 - QuantumX Configuration Panel

- **IP Device:** allows you to select the IP address of the instrument among the available IP addresses.

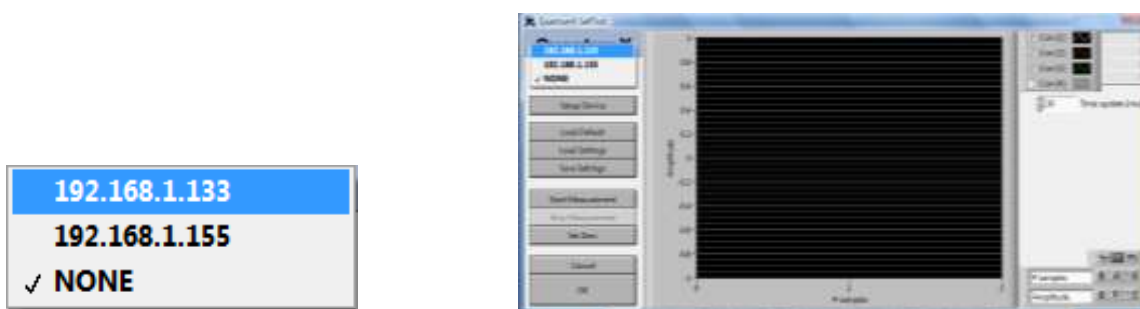


Fig. 4.15 - IP address choice



NOTE:

Be sure that the IP address of the chosen amplifier is correct and that the amplifier is correctly present in the local network.

- **Setup Device:** allows you to modify all the settings of the Quantum X amplifier



Fig. 4.16 - Setup Device windows

- **Load Default:** allows you to load the basic settings, once selected the IP address of the instrument.

**NOTE:**

This amplifier setting operation is possible only after you have selected the correct IP address, otherwise the error message in the image below will appear.

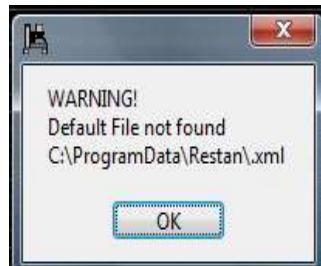


Fig. 4.17 - Error Message

- **Load Setting:** allows you to load a settings of the QuantumX already created (.xml file)
- **Save Setting:** allows you to save a settings of the QuantumX already created (.xml file)

**NOTE:**

If Load Default button was already pushed, the suggested parameters of the QuantumX amplifier are already introduced in the RSM software. We recommend to set as default the QuantumX parameters using the MTS3000 system.

- **Start Measurements:** allows you to start acquiring data from the strain gage rosette

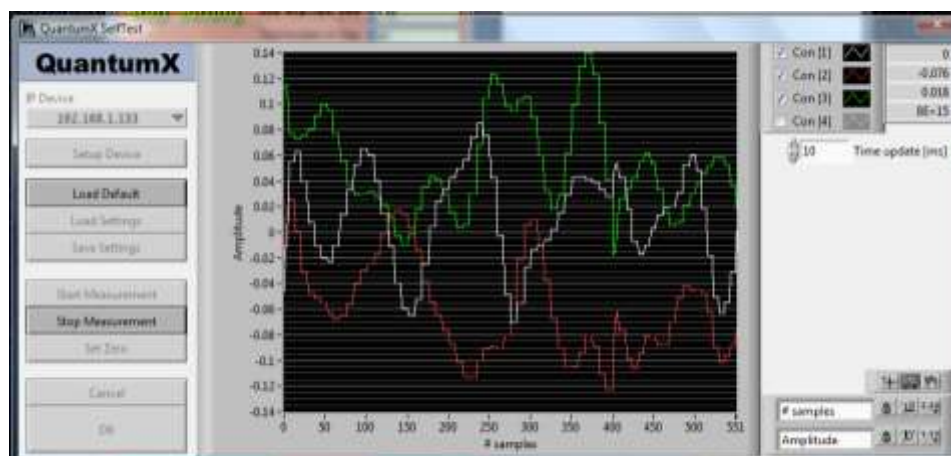


Fig. 4.18 - Strain gage reading

- **Stop Measurements:** allows you to stop acquiring data from the strain gage rosette
- **Set Zero:** allows you to put in zero the the strain gage rosette reading
- **Cancel:** allows you to exit from the QuantumX Configuration Panel
- **OK:** allows you to save all the paramethers set in the QuantumX Configuration Panel

4.7.4. ESPRESSO DAQD430

For more detailed information on the **EspressoDAQ D430** refer to the related HBM manual. The following parameters have to be specified in the window reserved for setting these instruments:

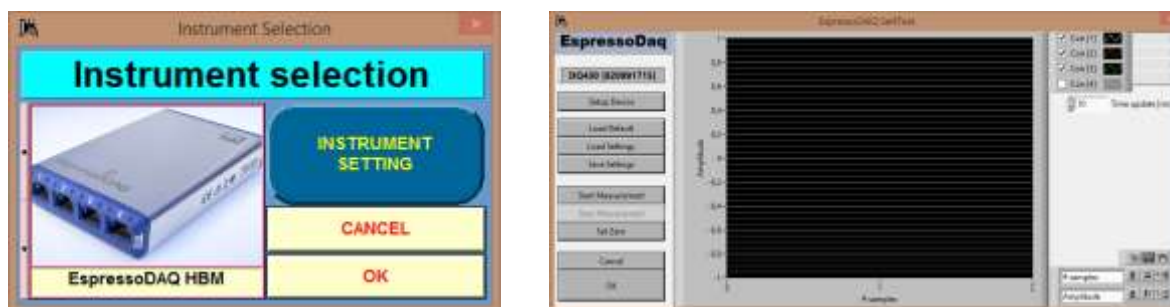


Fig. 4.19 - EspressoDAQ D430 Configuration Panel

- **Setup Device:** allows you to modify all the settings of the EspressoDAQ D430 amplifier



Fig. 4.20 - Setup Device windows

- **Load Default:** allows you to load the basic settings, once the amplifier is connected with the USB port of the PC



NOTE:

This amplifier setting operation is possible only after you have connected the amplifier in the USB port, otherwise the error message in the image below will appear.

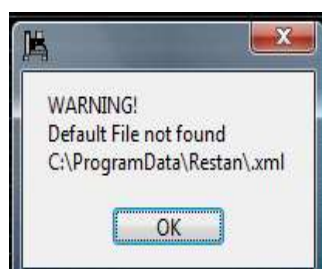


Fig. 4.21 - Error Message

- **Load Setting:** allows you to load a settings of the EspressoDAQ D430 already created (.xlm file)
- **Save Setting:** allows you to load a settings of the EspressoDAQ D430 already created (.xlm file)

**NOTE:**

If Load Default button was already pushed, the suggested parameters of the QuantumX amplifier are already introduced in the RSM software. We recommend to set as default the EspressoDAQ D430 parameters using the MTS3000 system..

- **Start Measurements:** allows you to start acquiring data from the strain gage rosette

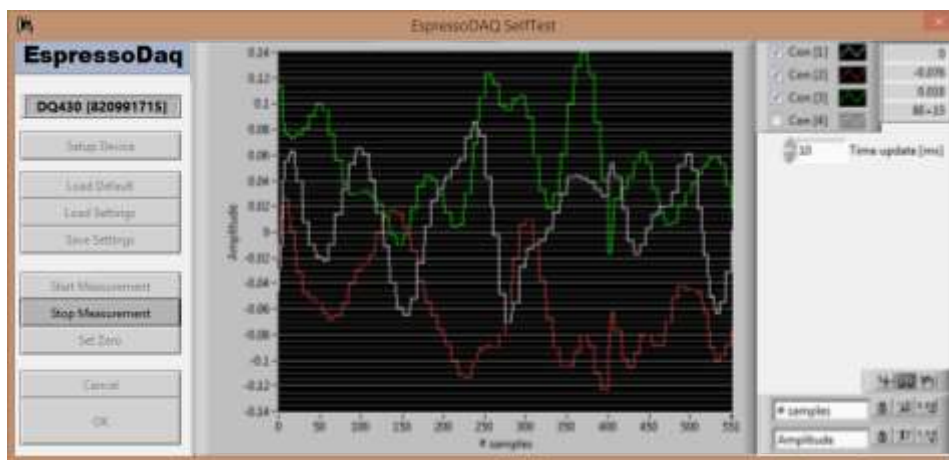


Fig. 4.22 - Strain gage reading

- **Stop Measurements:** allows you to stop acquiring data from the strain gage rosette
- **Set Zero:** allows you to put in zero the the strain gage rosette reading
- **Cancel:** allows you to exit from the EspressoDAQ D430 Configuration Panel
- **OK:** allows you to save all the parameters set in the EspressoDAQ D430 Configuration Panel

4.7.5. PCI 6023E and DAQCARD 6024E (on request)

For further information on cards PCI 6023E and DAQ Card 6024E, refer to the respective National Instruments manuals.

Both these cards can be used for acquiring signals from a standard strain gauge amplifier. Like many cards of this type, they have a ± 10 V input signal that fixes the maximum sensitivity that can be set on the strain gauge amplifier so that the card's input range is not exceeded. However, the card is protected up to signals of ± 45 V thus preventing risks of excess input voltage.



Fig. 4.23 - PCI 6023E configuration panel



Fig. 4.24 - DAQCard 6024E configuration panel

The following parameters relating to the analog amplifier and acquisition values have to be entered in the configuration windows for these two cards (Fig. 4.23 and Fig. 4.24):

- **Sensitivity [mV/V]:** sensitivity in [mV/V] set on the analog amplifier used for testing
- **Strain gage supply [V]:** supply voltage of the strain gauge bridge [V]
- **Max output:** maximum output in [V], corresponding to the full scale of the amplifier used for testing
- **Scan rate:** acquisition frequency in [Hz]
- **Samples:** number of samples read for each channel (enter the mean value).

The PCI 6023E and DAQCard6024E windows also contain the following functions:

- **Single Read:** for taking a single reading of strains
- **Continuous Read:** for taking a continuous reading of strains
- **Tare Balance:** for balancing the reading of the strain gauge bridge
- **Balance On/Off:** for activating/deactivating bridge balancing.

4.8. Setting General Data

When the **GENERAL DATA SETTING** function is selected, a dialog window (Fig. 4.25) appears for entering the following information:

- **Date:** date of test. By clicking on “Now” the software automatically enters the computer date.
- **Operator:** name of the operator conducting the test.
- **Place:** place where the test is carried out.
- **Test description:** reference information for test traceability.
- **File path:** path of the file where the data is to be saved (the function “Set path and file” opens a dialog box which helps select the desired path).

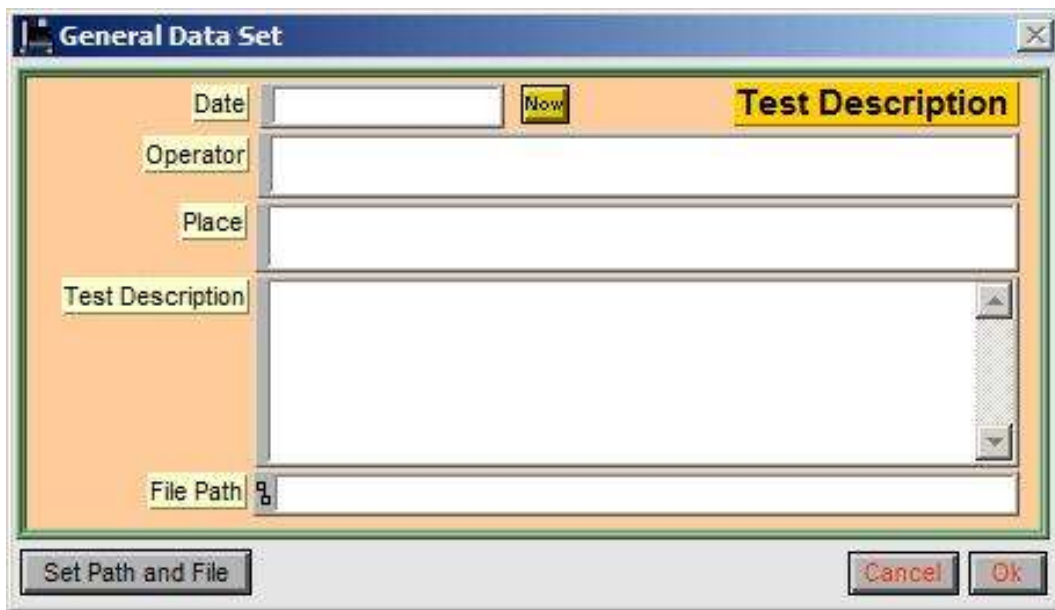
The image shows a software dialog box titled "General Data Set". It contains several input fields: "Date" with a "Now" button next to it, "Operator", "Place", "Test Description" (a large text area), and "File Path" with a folder icon. At the bottom, there are three buttons: "Set Path and File", "Cancel", and "Ok".

Fig. 4.25 - Panel for saving general test information

Select **OK** to save all entered data and go back to the **TEST SETUP** window or **CANCEL** to exit without saving any information.

4.9. *Setting the strain gauge rosettes*

The type of rosette used in testing is specified in the Strain Gauge Setting frame. Correct setting of the related parameters associated with the strain gauge rosette, and indicated by the manufacturer on the packaging, is of fundamental importance for allowing the software to derive the related geometric data.

The type of strain gauge used can be selected straight from the ring menu next to the schematic diagram of the strain gauge (Fig. 4.3 and Fig. 4.4), or by clicking on the image, accessing a pull-down menu and choosing from one of the following predefined options:

- HBM: 1-RY61-1,5/120K
- HBM: 1-RY61-1,5/120S
- HBM: 1-RY61-1,5/120R
- HBM: K-RY61-1,5/120R
- HBM: K-RY61-1,5/120M (special 4 grids rosette)
- HBM 1-VY61-1,5/120S (special 6 grids rosette)
- M-M: EA-031RE-120
- M-M: EA-062RE-120
- M-M: CEA-062UL-120
- M-M: CEA-062UM-120

- M-M: EA-125RE-120
- CW Custom Rosette
- CCW Custom Rosette

Without specific references (Custom), the software assigns the nominal gauge factor provided by the manufacturer of the selected rosette by default. The related value is shown directly under the Gauge Value pull-down menu with the average diameter of the rosette in [mm].

The gauge factor of the strain gauge rosette can be specified by setting “Custom” in the Gauge Value pull-down menu, and clicking on “Customize Rosette” thus opening a dialog window (Fig. 4.26) for entering the related Custom Strain Gauge Factor. The other options are disabled as one of the predefined strain gauge rosettes is selected.

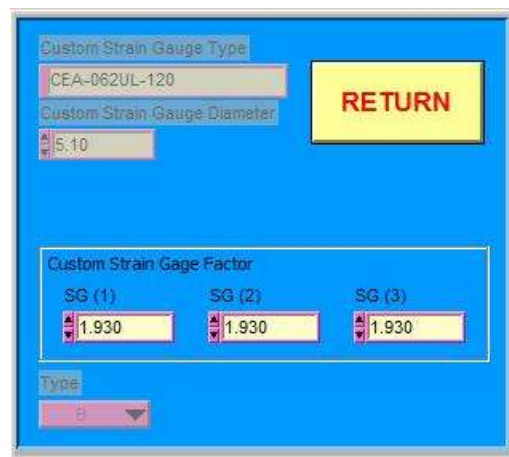


Fig. 4.26 - Dialog window for characterizing the strain gauge rosettes

If the strain gauge rosette that is used is not included in the predefined options, it is still possible to completely characterize a rosette by selecting one of the two generic rosettes from the pull-down menu, CW Custom Rosette (clockwise) or CCW Custom Rosette (counterclockwise), and then selecting “Customize Rosette” which allows all the data to be entered in the related window (Fig. 4.26). The parameters that can be specified are:

- **Custom Strain Gauge Type:** for indicating the name of the rosette
- **Custom Strain Gauge Diameter [mm]:** for entering the average diameter of the rosette in [mm]
- **Strain Gauge Factor:** for entering the standard gauge factor of the rosette
- **Custom Strain Gauge Factor:** for specifying the gauge factor of the rosette as indicated by the manufacturer on the packaging
- **Type:** for entering the type of rosette (A - B) in accordance with standard ASTM E837-13.

All the settings made in the Test Setup window can be saved in a file by selecting **SAVE CONFIG** (Fig. 4.3 and Fig. 4.4). A dialog window box opens so that the configuration file

can be given a name, with extension “.cfg”. All saved configurations can then be called up via the “Load Config” function (Fig. 4.3 and Fig. 4.4). It is generally good practice to always save the test configuration, even if for one hole only. It is of fundamental importance for keeping track of all the parameters and for being able to reinstate them easily if a test is to be restarted and terminated (Chapter 5). By selecting **OK** you exit from this window (Test Set) maintaining the test configuration you have just set whereas if you select **CANCEL**, the window closes maintaining the previous test configuration.

4.10. Default Settings

Selecting **DEFAULT SETTING** (Fig. 4.1) opens a window (Mechanical and Device Setup Default Setting – Fig. 4.27) with the following options:



Fig. 4.27 - Default Setting dialog window

- **MECHANICAL SETUP:** click on this to change the screw pitch value [mm/r]. The value obtained during calibration is indicated in the related calibration certificate (MOD 07 26), and the software requires it to be entered at the first run. A password is needed for any further modifications (please contact Customer Assistance at support@sinttechnology.com).
- **SAVE CURRENT SETTING AS DEFAULT:** allows you to save the current settings in the software configuration file.



WARNING:

The software operates with the parameters set in this window (Default Setting) even without saving the modifications. However, when you log off, it automatically retrieves the original configuration. To permanently modify the settings, you have to always save them before logging off with **SAVE CURRENT SETTING AS DEFAULT**. The existing default file will be overwritten (although a message will appear asking you to confirm this option).

- **RETURN:** takes you back to the main menu (Fig. 4.1).

4.11. Test Manager



WARNING:

Before accessing Test Manager the zero level of the end mill (Section 4.2) corresponding to the surface of the specimen has to be identified. It is the position that the software takes as a reference for giving the hole depth. The software does not allow access to this window unless it is identified.

On selecting Test Manager a window opens that allows you to see all drilling test parameters (Fig. 4.28).

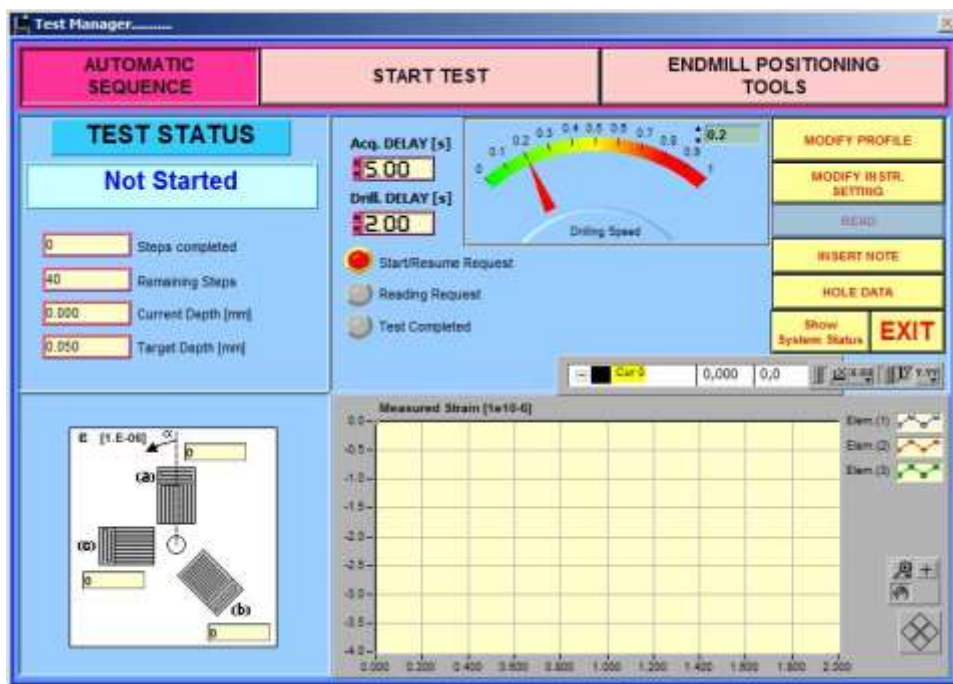


Fig. 4.28 - Test Manager window

The window contains the following options for running and monitoring the procedure:

- **STEP-BY-STEP SEQUENCE / AUTOMATIC SEQUENCE:** allows you to select the hole drilling procedure (Section 0).
- **START TEST:** allows you to start a test (START TEST), or continue one at the end of a single reading (NEXT STEP), or to complete the current drilling step if there has been an emergency stop (COMPLETE TEST).
- **ENDMILL POSITIONING TOOLS:** allows direct access from the current window to the Positioning Control window (Section 4.1) by selecting ENDMILL POSITIONING TOOLS (Fig. 4.28). You can access this window at any time throughout testing simply by clicking on the relevant button (in Automatic Sequence you have to go to Step-By-Step Sequence before starting a new drilling step), even during a drilling step by hitting the Emergency Stop. The Emergency Stop should only be used in real emergencies. Whenever you exit from the Positioning Control window (irrespective of the operation

that has been conducted), the program automatically moves the end mill back to the level at which the Positioning Control window was activated.

- **Test Status:** gives information on testing progress, such as:
 - **Not started:** test at a standstill, the system is waiting to start
 - **Completed:** test finished
 - **Emergency stop:** the test has been stopped by the operator during testing or by the software as there is some reason for not being able to continue (e.g., a limit switch cutout)
 - **Waiting for reading:** dwell prior to reading strains
 - **Waiting for drilling:** dwell prior to executing another drilling step.

Some information is also signaled by the three lights at the side of the Test Status window (Fig. 4.28):

- **Start/Resume Request:** the system is waiting to start/continue a test
- **Reading Request:** the system is waiting for reading of strains
- **Test Completed:** test terminated,

and by the four numerical indicators below it:

- **Steps completed:** the number of steps completed
 - **Remaining steps:** the number of steps left to complete the hole
 - **Current depth [mm]:** the current depth of the hole
 - **Target depth [mm]:** the end depth of the next step.
- **Drilling Speed [mm/min]:** enables you to set the end mill feed rate, changing the rate by the needle or numerical indicator, during any stage of testing except during a drilling step. The speed displayed when this window is opened is the one initially set in the Positioning Control window (Fig. 4.2- Section 4.1).
 - **Acquisition Graph:** The graph at the bottom shows the trend of strains versus hole depth during testing while the frame on the left of the graph shows the last strains read on the three strain gauge grids.
 - **Modify Profile:** allows you to modify the number of steps in a hole thus changing the end depth of the hole (Fig. 4.29). The number of steps can be changed even during the drilling of a hole by selecting this function before running a new drilling step (Step-By-Step Sequence procedure), or by going to Step-By-Step Sequence and selecting the related function before starting the new drilling step (Automatic Sequence procedure).



Fig. 4.29 - Modify Profile window

- **Modify Instr. Setting:** allows you to change the settings of the measuring instrument (Fig. 4.30). You can access this window even during hole drilling, at the end of every drilling step, by changing to Step-By-Step Sequence – if the Automatic Sequence procedure is operative – and selecting the related function. However, it is impossible to reset the offset of the three strain gauge grids to zero (the function is disabled by the system and colored grey accordingly).

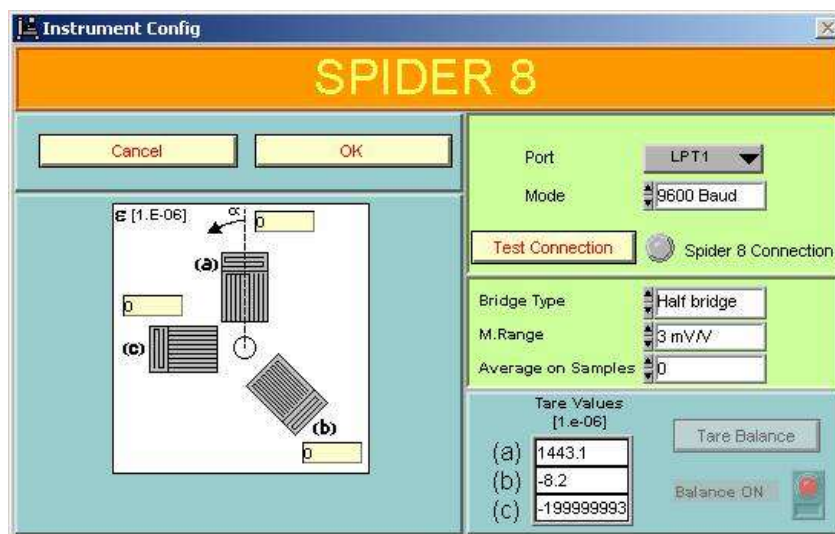


Fig. 4.30 - Modify Instr. Setting window

- **Read:** allows you to take a manual reading of strains on the three strain gauge grids. This function is used whenever the system is running on Step-By-Step Sequence. Strains can be read as often as you like before starting a new drilling step (Repeat Read) but the system only memorizes the last reading.
- **Insert Note:** saves test notes along with test data. Notes cannot be any longer than 50 characters as any extra text is automatically cutoff.
- **Hole Data:** is for entering hole dimensions X+, X-, Y+ and Y- (Fig. 4.31), for the program to calculate the following parameters:

- Mean hole radius [mm]
- Eccentricity radius [mm]
- Eccentricity angle [°].

Hole data can be changed at any following processing stage. If you exit from Test Manager without entering data in HOLE DATA, the program automatically asks for the information. If you then select OK, the system closes the window setting all the parameters at zero.

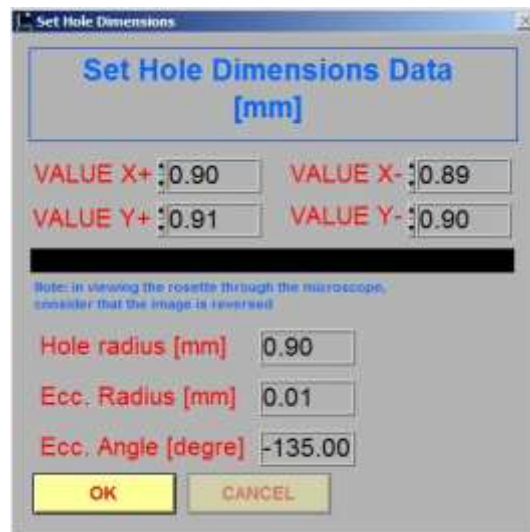


Fig. 4.31 - Hole Data window

- **Show System Status:** at the bottom left of the command area, allows you to see the communication status and settings of the electronic control system.
- **Exit:** select this to close the current window (Fig. 4.28) and go back to the main menu (Fig. 4.1). If a test has been completed (Test Completed indicator red), the software automatically opens the Hole Data window (Fig. 4.31) to go back to the main menu, by selecting OK or CANCEL, marking saved data as complete (TEST STATUS=ON). If a test has not been completed (Test Completed indicator off), the software opens the following dialog box :

Test not completed
Do you really want to exit?

If the answer is yes, the software automatically accesses the Hole Data window (Fig. 4.31) to go back to the main menu via OK or CANCEL but marking saved data as interrupted (TEST STATUS=OFF).

4.12. Carrying out a test

Hole drilling and related measurements can be done with two different procedures that are selected by the button at the top left of the Test Manager window:

- Step-by-Step sequence
- Fully automatic sequence.

When you access **TEST MANAGER**, the software selects the **STEP-BY-STEP SEQUENCE** (Fig. 4.28) shown by the wording on the function key. To change over to the **AUTOMATIC SEQUENCE** simply click on the same function key (Fig. 4.33), which will then read accordingly. Re-selecting will switch back to the **STEP-BY-STEP SEQUENCE**. You can change over from one hole drilling procedure to the other during testing by simply selecting this option at the end of any drilling step before beginning the next one.

To start the hole drilling sequence, select **START TEST**. The software automatically opens the **General Data Set** window (Section 4.8 – Fig. 4.25), where you can specify or alter set test parameters (including the name and file path for saving test data). On selecting OK the software opens the dialog window for the instrument selected in Test Setup (Section 4.3) to reset the strain gauge grids. On selecting OK again the software starts the first drilling step of the selected procedure.



WARNING:

To start a test, the operator has to specify a name and file path for saving test data and reset the three elements of the strain gauge rosette otherwise the software will not start the first drilling step of a test.

4.12.1. Step-by-Step Sequence

To enable this type of procedure, select **STEP-BY-STEP SEQUENCE** in the top left corner (Fig. 4.28).

- When **START TEST** is selected (after balancing the offset, as previously described), the system starts the first drilling step opening the related control window (Fig. 4.32), showing information on the current step:
 - **Drilling Speed [mm/min]:** shows the end mill feed rate set in the Test Setup window (Section 4.3) or Test Manager (Section 4.11)
 - **Target Depth [mm]:** shows the end penetration depth of the current drilling step in [mm]
 - **Current Depth [mm]:** shows the depth of penetration of the end mill in [mm]
 - **Emergency Stop:** instantaneously stops the hole drilling procedure returning to the main window (Fig. 4.28)

There are also pilot lights, as previously described, showing the status of the electronic control system. (Section 4.1).

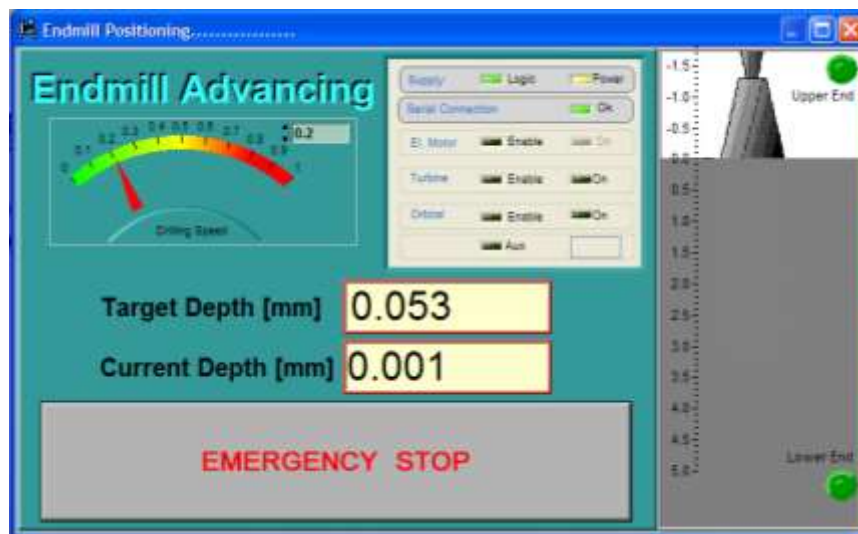


Fig. 4.32 - Hole Drilling window

- When you reach the final depth of a drilling step, the system automatically stops end mill feed, the hole drilling window closes and the system goes on dwell until released strains are read on the strain gauge grids (Reading Request light red - Fig. 4.28). To do so, click on **READ** (Fig. 4.28), which at the same time enables testing to continue (Resume Request light red, NEXT STEP function enabled). Strain readings can be repeated by selecting **REPEAT READ** instead of READ after the first reading.
- Select **NEXT STEP** to start another drilling step.
- Repeat until the hole is completed (Test Completed light red – Fig. 4.28).
- Enter the hole dimensions by clicking on **HOLE DATA**, or **EXIT** to close the window and go back to the main menu (Fig. 4.1).

Please note that:

- When you activate the **EMERGENCY STOP** in the Hole Drilling window (Fig. 4.32) when drilling is in progress, you automatically stop the test and go back to the **TEST MANAGER** window (Fig. 4.28). Once you have eliminated the cause of an emergency stop, you will have to select **COMPLETE TEST** (which is equivalent to START TEST – Fig. 4.28) to terminate drilling of a hole. The software will automatically complete the drilling step to the set depth and continue the test by the selected procedure (Step-By-Step Sequence or Automatic Sequence).
- The NEXT STEP function is disabled until a reading is taken of strains released by the previous drilling step.

4.12.2. Automatic Sequence

To enable this type of procedure, select **AUTOMATIC SEQUENCE** in the top left corner of the Test Manager window (Fig. 4.33). The hole drilling procedure will be run automatically by the software based on your setting of the Drilling Speed [mm/min], Acquisition Delay (the time before automatically reading strains and resuming testing with another drilling step) and Drilling Delay.

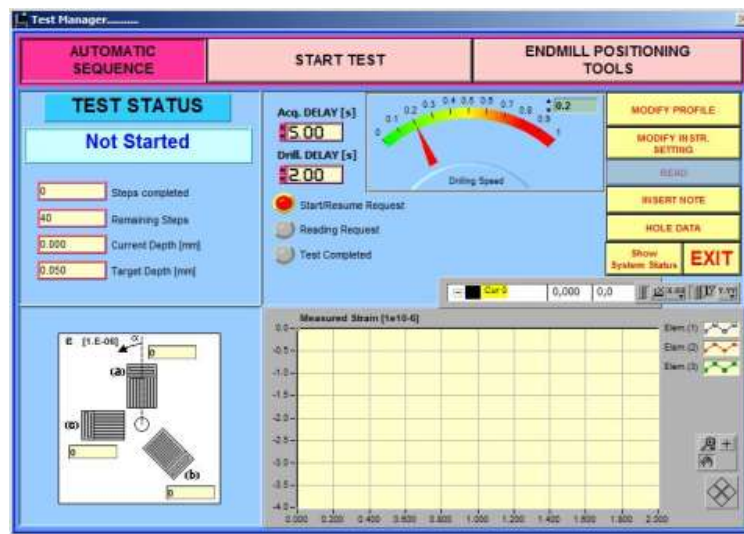


Fig. 4.33 - Automatic Sequence window

The fundamental difference between this hole-drilling procedure and the one previously described is the fact that the software totally automatically handles the operations that were previously done by the operator at the end of every drilling step, saving time.

**WARNING:**

Running the Automatic Sequence procedure does not mean that the system can be left unmanned during testing. An operator should check that the measurements are taken correctly and intervene during drilling in the event of any emergency that can affect the test or the equipment.

Please note that:

- When **EMERGENCY STOP** in the Hole Drilling window (Fig. 4.32) is selected during drilling, the test is automatically stopped and the **TEST MANAGER** window (Fig. 4.28) opens. Once the cause of an emergency stop has been eliminated, **COMPLETE TEST** (which is equivalent to **START TEST** - Fig. 4.28) has to be selected to terminate drilling of a hole. The software will automatically complete the drilling step to the set depth and continue the test by the selected procedure (Step-By-Step Sequence or Automatic Sequence).
- The software automatically introduces a 3-second delay. The length of the delay can be changed at any time during testing except for during drilling. The **ACQUISITION DELAY** allows having a stable reading of the strain gages values.
- The option **DRILLING DELAY** allows the turbine to perform, at the end of each step, a hole with a better finishing (and in particular more flat).

4.13. Restore Interrupted Test

During testing the software saves the strain readings in a file identified by the operator but also the current penetration depth in a temporary file created and managed by the software. This value is retained in the memory of the PC until another test is started (procedure for identifying the surface of the specimen). As a result it is always possible to resume testing after an interruption.

Restore Interrupted Test (Fig. 4.1) should therefore be selected when you want to recover an interrupted test in order to complete the remaining steps in the sequence. The following message requires this option to be confirmed:

WARNING!!
RESTORING THE LAST INTERRUPTED TEST
ALL CURRENT DATA IN MEMORY WILL BE LOST.

The warning obviously refers to the last depth reading taken by the software prior to the interruption. It is, however, worth copying the file containing the strain data saved in the first part of the interrupted test.



WARNING:

Interrupted tests can be restored only if the end mill is in the same position as it was when the test was interrupted. It is, therefore, essential not to do any manual movements.

When you select Restore Interrupted Test, the program automatically initializes the procedure in Test Manager (reading the last depth as current in the related position file), requesting the interrupted test data file to be loaded. Once the file is loaded, the system goes on dwell for the hole drilling (Waiting for Drilling). Select the desired hole configuration (hole-drilling method, Speed, Drilling Delay, Acquisition Delay if on Automatic Sequence) and start completion of the test. The software completes the remaining steps. If you try to restore a test that does not correspond to the last one (interruption depth not matching the last one saved), you get the following message:

WARNING!!
Data File does not correspond to the
position file.



NOTE:

Before accessing this window to complete a test you have to re-configure the software (Test Setup – Section 4.3) or retrieve the saved configuration file (.cfg).

5. DRILLING A HOLE AND BACK-CALCULATION

A test is conducted in the following stages:

- Prepare the system
- Set up the test
- Drill the hole / Record strain data
- Back-calculation.

5.1. *Safety precautions*

The following general notes are to be considered fundamental for good test results with this system.

- The test may be done by one operator but if the system is installed on a surface that is not perfectly horizontal two operators are required.
- Installing the strain gauge rosette, wiring and generally all procedures to be followed to install the strain gauge system may be done by a different operator from the one who conducts the test with the system.
- During a hole-drilling procedure the operator's tasks are to:
 - Attend to the personal computer and electronic control system during the stages of preparation for the test, drilling of the hole and following re-processing. The drilling and strain measurement procedures are fully automated so the mechanical drilling system need not be manned.
 - Attend to the mechanical-optical system during calibration, positioning and measurement of hole diameter and eccentricity.



WARNING:

Safety goggles are obligatory whenever an operator is near the mechanical-optical system when it is in operation. (Eyes protections is not supplied with the system).



WARNING:

Safety ears protectors are obligatory whenever an operator is near the mechanical-optical system when it is in operation. (Ears protections are not supplied with the system).

5.2. Connections

Before carrying out a test, the system has to be prepared and the connections made in relation to the drilling system to be adopted. The sequence of connections to be made depending on the system to be used has been described in the diagram of the connections (for the standard system is shown in Fig. 1.1).

During the stage of zero-setting the specimen surface it is also necessary to connect the specific cable of the electronic control box (if present) with the surface of the material the test is to be conducted on.

The strain gauge amplifiers connected to the electrical resistance strain gauges have to be connected directly to the PC in accordance with the manufacturer's specifications (connection using Ethernet or USB port) if it's are digital.



WARNING:

The connections to the strain gauges have to conform to the specifications of the related strain gauge amplifier manuals.

5.3. Installing and wiring the strain gauge rosette

Bonding the strain gauge to the surface of the test object, the wiring and the strain gauge amplifier settings have to be performed in accordance with the procedures provided by the manufacturer of the electrical resistance strain gauge and strain gauge amplifier that are used.

The quality of the measurements depends on correct use of the strain gauge rosette in accordance with current procedures and standards regarding residual stress. It is imperative that these procedures are carried out by competent technicians. However, bonding of the strain gauge need not to be done by the operator.

5.4. Setting test parameters and choosing the end mill

The selection of the test parameters have to be done using the Setting menu windows of the RSM software.

In the window the following parameters have to be specified:

- Number and distribution of drilling steps (Step Setting)
- Identification of the model of strain gauge rosette used (Strain Gauge Setting)
- Properties of the material (Material Type)
- Setting of the acquisition instrument (Instrument Setting)
- General test data (General Data Setting).

5.5. Setting the sensitivity of the strain gauge amplifier (only for analog amplifiers)

The strain gauge rosette used for testing may be connected to a digital or an analog amplifier. If digital amplifiers are used the acquisition parameters and sensitivity are controlled totally automatically according to the settings selected by the operator in the software (**Instrument Setting**). If analog amplifiers are used these parameters have to be controlled by the operator depending on the settings selected on the actual amplifier as the software cannot communicate with the amplifier.

The following example illustrates the considerations and calculations the operator has to make to correctly set the acquisition software. To achieve this, it is necessary to do the following calculation:

$$\varepsilon = \frac{4}{n * K} * \frac{\Delta V}{V}$$

where:

- **n** is the number of active elements
- **K** is the gauge factor of the strain gauge
- **ΔV/V** is the sensitivity of the bridge.

Supposing that the analog amplifier is set as follows:

- Strain gauge bridge connection: ¼ bridge (1 active element)
- Strain gauge bridge input: 5 V
- Input sensitivity: 1 mV/V
- Full scale of the instrument's display: 2000.

and that the gauge factor (K) of the strain gauge grids is 2, it follows that:

$$\varepsilon = 2 * 0.001 \text{ V/V} = 0.002 * 10^6 = 2000 \text{ } \mu\text{m/m}.$$

Therefore, if 10 V corresponds to the full scale of the display (2000) then it is equivalent to 2000 $\mu\text{m/m}$, and 5 V to 1000 $\mu\text{m/m}$.

If sensitivity is 0.5 mV/V, then 5 V output is equivalent to 500 $\mu\text{m/m}$, etc. So the correct value has to be selected dependent on the acquisition that you intend to do, accounting for the signal amplitude that is expected to be measured throughout the test.

It is, however, important to make sure that the full scale of the analog amplifier does not exceed the maximum input voltage of the acquisition channel. At worst, however, the accuracy of the analog/digital converter in the amplifier guarantees a resolution of 1 μe .



WARNING:

For the setting of the analog amplifier used for the acquisition, please refer to the manual of the manufacturer.

5.6. Positioning and centering the mechanical-optical device



WARNING:

Accurate calibration of the device (Section 3.3.6) is essential for correct positioning of the mechanical-optical system and consequently for a test to be dependable. Therefore, make sure that the device is calibrated in accordance with the instructions provided in this manual before carrying out any testing.



WARNING:

Positioning and centering of the mechanical-optical device can only be done when the turbine is stopped and the device is not moving. During this procedure, do not start the turbine under any circumstances.

The first operations to be done for any test are positioning and centering of the mechanical-optical device. Positioning consists in:

- Determining the optimum position of the device in relation to the strain gauge rosette and to the surface
- Centering the drilling axis of the device over the target of the rosette
- Fixing the device on the measuring point if the position is such that safety or correct execution of the test cannot be guaranteed.



WARNING:

The device must be positioned so that there is no risk either for the equipment or for the operator during this procedure and all following operations. For this reason, wherever there is a danger for the operator or for the equipment, the device must be adequately secured in relation to the operating conditions.

To position the device and center it, proceed as follows:

- Position the slide for horizontal movements along the X – Y axes in the center of the useful travel area.
- Position the device near the center of the hole to be made in the center of the rosette. The turbine support can be left in the drilling position, as the device has only to be roughly positioned to guarantee parallelism between the metal surface and the end mill. To do this, it may help to adjust the height and angle of the three feet, checking perpendicularity with an L-square, for flat surfaces, or checking parallelism between the two surfaces from two perpendicular directions, after moving the end mill closer to the metal surface, with a narrow-beam light. The end mill should always be moved away from the surface of the strain gauge when the feet of the mechanical-optical device are being adjusted to avoid any damage.

- After having positioned the device and checked its perpendicularity, lock all three nuts tightening the feet. This guarantees stability of the mechanical-optical device during the drilling of a hole when the magnets in the feet ensure good anchoring to the surface of the material.
- Observing the center of the hole through the microscope (Fig. 1.2 – Section 1.2), move the device in directions X and Y by the two adjustment knobs (**Part n° 14**, Fig. 1.3 - Section 1.3) perpendicular to the drilling axis of the end mill. Align the center of the microscope target with the reference on the strain gauge rosette. This step of the procedure should be done accurately to assure that the system operates correctly in the acquisition stage.
- Reset the X and Y-axis dial gauges by the outer ring nuts (**Part n° 18** and **Part n° 19**, Fig. 1.3 - Section 1.3).
- When you are certain that the alignment is perfect, fix everything on the work surface (using HBM-X60 adhesive).

**WARNING:**

The device has plastic feet to assure that the mechanical system is isolated from the metal surface of the test material.

Such electrical isolation must still be guaranteed by the system for the next resetting stage (Section 5.8 Fig. 5.2).

**NOTE:**

Rough alignment of the end mill (steps 1 to 4) must assure that the X – Y slides travel sufficiently to allow the hole dimensions (X+, X-, Y+, Y-) to be read later. Should this not be possible, re-position the mechanical-optical device so as to effect a smaller movement along X and Y.

5.7. *Resetting the strain gauges*

Initial strains read by the strain gauges have to be cleared during setting of the gauges from the control window of the selected instrument (Instrument Setting window, Section 4.7).

The initial unbalance (in $\mu\text{m/m}$) of the strain gauge grids can be checked using a single read. If it is not near zero, select Tare Balance and save the value thus defined as offset. Determination of zero can be repeated also later when wanted. In any case, you are automatically asked to clear read strains before beginning hole drilling (Test Manager window, Section 4.11).

**NOTE:**

When a significant initial unbalance (comparing with the full scale reading) is noted, it is always better to do an external balancing using a shunt resistor or any balancing systems on the strain acquisition system as the operating range of the readings that can be taken risks being excessively reduced.

5.8. Determining the surface of the material (zero setting)

Before drilling a hole, it is necessary to identify the surface of the test material which coincides with zero hole depth (Zero Setting). This depth is defined by the point of contact between the drill and metal.

The system is able to exactly identify contact between the metal material and drill by measuring the electrical resistance between the surface of the material and the drill. This operation is guaranteed by the isolation between the mechanical-optical device and the metal surface of the test material. The procedure for identifying the zero depth uses an alligator clips cable (zero setting cable) that have to be connected with the test material (alligator clips side) and the mechanical device of the MTS3000 system.

In the following paragraph, there will be reported the steps that has to be performed in the visual and electric sequence.



NOTE:

Determining the surface is very important for drilling a hole correctly and measuring released strains. It is important that the mechanical system is electrically isolated from the work surface. Any operation that does not assure this isolation could compromise correct identification of the zero depth and as a result the association between the depth and measured strains.

5.8.1. Visual sequence (MANUAL - alternative to Electric sequence)

Visual zero setting sequence (Manual sequence) is generally not suggested and has to be carried out if for any reason the automatic sequence can't be used.

When the Visual sequence is selected, the following steps have to be performed:

- Move the end mill close to the surface using the fast vertical adjustment (Part n° 9, Fig. 1.3 - Section 1.3). It has to be moved as close as possible to the surface of the strain gauge backing although avoiding contact with the actual surface. Then fix the slide in this position with the vertical slide lock (Part n° 16, Fig. 1.3 - Section 1.3).
- Set the strain gage amplifier and put in zero the reading of the strain gage.
- Activate the air turbine and click on the pushbutton **“Forward”**: it causes an advancing of the endmill.
- When the dust of the strain gage is produced around the endmill, stop immediately the advancing.
- Verify the reading of the strain gage amplifier: if the reading is still zero, repeat the last 2 step reported above. At the end of this process, the final position will be assumed as zero reference for the hole drilling measurement.
- Click on **“Assume Current Position as Zero”**.
- Select **EXIT** to quit the procedure and access the hole drilling stage (Test Manager).

5.8.2. Electric sequence (AUTOMATIC)

The procedure for identifying the zero depth uses the BNC cable/alligator clips (zero setting cable) that must be connected between the electronic control system (BNC side) and the device/test material (alligator clips side). When the Electric sequence is selected (Automatic sequence), the following steps have to be performed:

- Connect the zero setting cable on the BNC side to the rear panel of the electronic control unit (**Part n° 4**, Fig. 1.6 - Section 1.4).
- Connect the zero setting cable on the alligator clips side (Fig. 5.2) between the test material and the screw for the purpose on the casing (**Part n° 26**, Fig. 1.3 - Section 1.3). As far as concerns the material, should you not manage to find a suitable attachment point, you can use a magnet (not supplied with the system) making sure that it is positioned where the material is not electrically isolated by paints, passivations or cadmium platings.



Fig. 5.1 - Centering

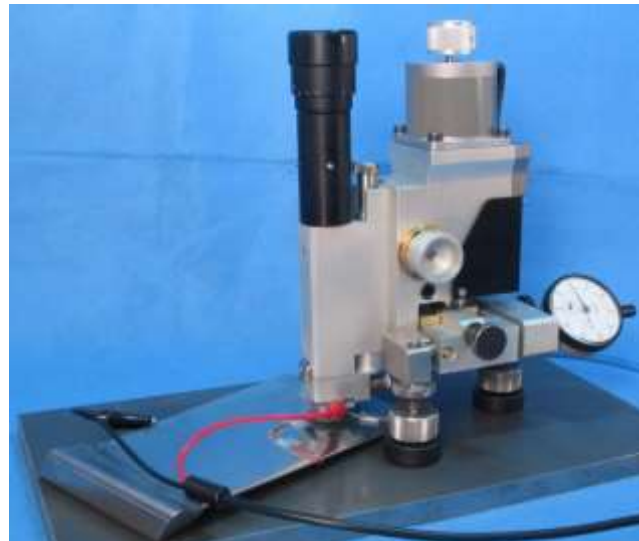


Fig. 5.2 - Determining the surface of the material (Zero setting)

- Move the end mill closer using the fast vertical adjustment (**Part n° 9**, Fig. 1.3 - Section 1.3). It has to be moved as close as possible to the surface of the strain gauge backing although avoiding contact with the actual surface. Then fix the slide in this position with the vertical slide lock (**Part n° 16**, Fig. 1.3 - Section 1.3).
- Select “Positioning Endmill on Surface” in the Positioning Control window (Section 4.1) to start the automatic procedure for identifying zero depth.
- The software warns you that the speed will be automatically reduced to 0.2 mm/min. When you click on **OK**, the system sets the end mill rotating and begins to move it towards the surface of the material. It is stopped when the strain gauge backing is removed and the end mill touches the surface of the metal making the electric contact. The software then displays the message:

Warning! Current position is assumed as reference for the hole depth.

Select **EXIT** to quit the procedure and access the hole drilling stage (Test Manager).

**WARNING:**

The zero depth is identified applying a low electric voltage across the alligator clips. Voltage is applied only during the zero setting procedure. However, it is good practice to disconnect the BNC cable/alligator clips from the rear panel of the electronic control unit and mechanical system once zero is identified.

5.9. Drilling the hole

During the hole drilling test, performed by the MTS3000-Restan system, the active presence of the operator could be not necessary: using the Automatic sequence, the presence of the operator is needed only for control the system during the drilling / acquisition process.

The last 2 operations can be simplified if the operator is using the Automatic sequence of the RSM software: on the contrary, using the Step by Step sequence, the presence of the operator is needed for the acquisition of the strain and for restarting the drilling process step by step..

In the following paragraph, the steps that have to be performed in the 2 cases will be reported:

- Drilling process is automatic but the recording of strain data after the end of the drilling step needs the confirmation of the operator (Step by Step Sequence).
- Drilling and acquisition processes are totally automatic up to the total depth specified by the operator (Automatic Sequence).

**WARNING:**

Eye protection must be worn by the operator working near the drilling device throughout the drilling stage to avoid the risk of eye injury from flying particles. (Personal protective eyewear is not supplied with the system)

5.9.1. Step-by-step drilling sequence

When the Step by Step drilling sequence is selected, the following procedure has to be performed

- Select the **STEP-BY-STEP SEQUENCE** function and enter the drilling speed. The drilling speed depends on the type of drill and the test material. Since it is impossible to provide a blueprint for every application, you are advised to always do at least one trial hole, without a rosette, to identify the most suitable drilling speed. As you acquire experience you will be able to judge the most suitable configurations more quickly.
- Select **START TEST** (Fig. 4.28). The software asks you to indicate the file where the data is to be saved and to clear the initial strain readings on the strain gauge grids (offset). Once these operations are completed the software automatically starts the end mill, which will start to carry out the first drilling step, contemporaneously presenting a window with the drill depth and the Emergency Stop.
- On reaching the set depth of the step, the window for execution of the drilling step closes and the drill automatically stops moving forward and rotating.
- Select **READ** to take a reading of the strains. The reading may be taken several times by selecting **REPEAT READ**. The value saved on file is the last value read. Every time a reading is taken, the measured voltage is displayed on the grid diagram and on the graph of strains read at the related measurement depth.
- Repeat the procedure from point 3 to 4 until all drilling steps are completed.

5.9.2. Automatic drilling sequence

By selecting this procedure the software carries out the steps described above by a fully automated system.

When the Automatic drilling sequence is selected, the following procedure has to be performed

- Select the **AUTOMATIC SEQUENCE** function and enter the drilling speed and the acquisition and drilling delay between the end of the drilling step and reading of the strains. To enable this procedure, you have to click on **STEP-BY-STEP SEQUENCE** to make the wording **AUTOMATIC SEQUENCE** appear on the key, as previously described (Section 0).
- Define the “**Acquisition Delay**” and the “**Drilling Delay**” for your measurement.
- Select **START TEST**. The software starts the hole drilling program, reading strains at the end of every drilling step, after a delay time matching the set time (“Acquisition Delay” and in case “Drilling Delay”), and then continues with the next drilling step until all steps are completed.
- To manually intervene in the running of the test, you must disable the automatic procedure by selecting **AUTOMATIC SEQUENCE** again and changing over to the **STEP-BY-STEP SEQUENCE** procedure.

5.10. Measuring hole diameter and eccentricity

This procedure can be done only after completing the hole. Proceed as follows:

- After the turbine has stopped, release and lift the slide using the vertical adjustment (**Part n° 16**, Fig. 1.3 - Section 1.3 and **Part n° 9**, Fig. 1.3 - Section 1.3).
- Turn the turbine support if using standard system, or change the electric motor with the microscope, making sure that the vertical slide is perfectly secured and the base is locked (**Part n° 16**, Fig. 1.3 - Section 1.3), so that you can see with the microscope. Still acting on the vertical adjustment of the slide and on the system for locking it, focus on the surface of the hole, coinciding with the surface of the material.
- If necessary, clean the hole and the area around it with a brush or a blast of air.



WARNING:

When cleaning the hole, the operator must wear eye protection (personal protective eyewear is not supplied with the system)

- Measure dimensions X+, X-, Y+ and Y- coinciding with the radius of the hole in the four directions along the 90° axes of the target. To do this, it is necessary to move the drilling device along the slide in direction X with the related adjustment (**Part n° 14**, Fig. 1.3 - Section 1.3) until the target line parallel to direction Y is at a tangent to the edge of the hole. Repeat this procedure for the second tangent point along the X-axis, and repeat it also in direction Y for the last two tangent points (**Part n° 9**, Fig. 1.3 - Section 1.3).

The main conventions used in the EVAL software are reported herebelow.

The following figures show the positive directions of the X and Y axis for each strain gage type (A or B) and for each strain gage convention (CW or CCW).

For the definition of these parameters, please refer to Chapter 5 of the EVAL manual.

Dimensions X+, X-, Y+ and Y- have to be entered in the window that opens when you select **Hole Data** in the RSM software. Values have to be entered in millimeters.

They can also be entered later during calculation of the residual stresses but it is better if they are recorded right after drilling the hole, making use of following opportunities only if strictly necessary. The results of a reading can be altered by metal particles around the edge of the hole making it difficult to establish the exact tangent point.



WARNING:

For the eccentricity correction, the MTS3000 system has to be placed with the traslation directions aligned with the X and Y direction of the reference system of the strain gage rosette.

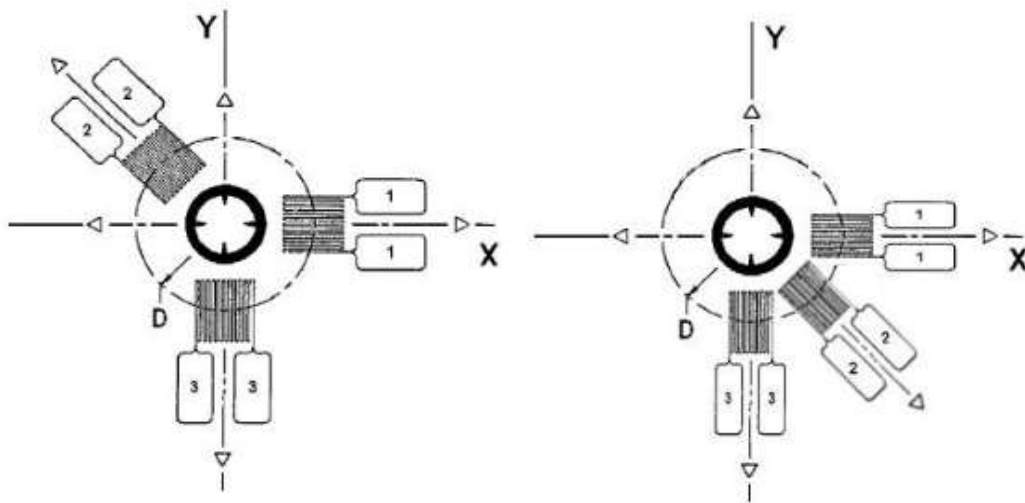


Fig. 5.3 – Convention used for the positive direction of the X and Y axis for CW rosettes (on left strain gage rosette type A, on right strain gage rosette type B).

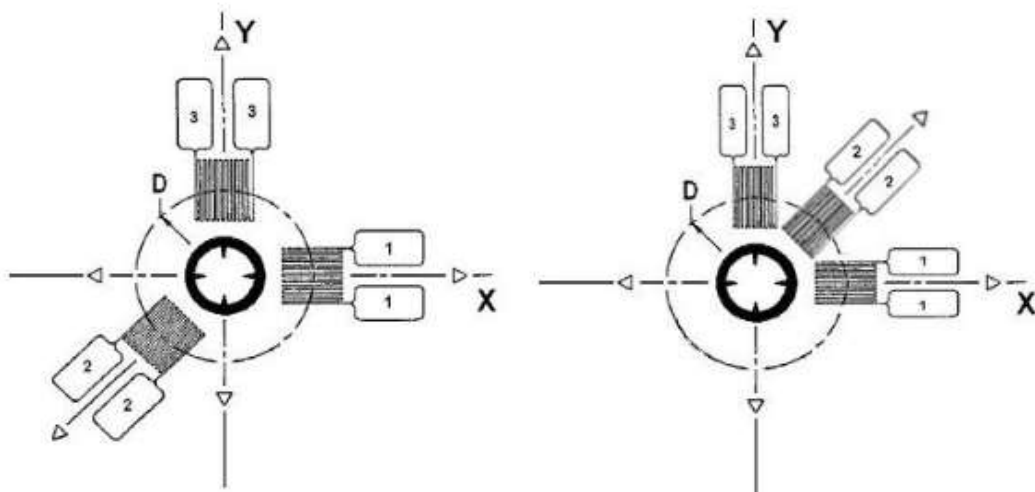


Fig. 5.4 – Convention used for the positive direction of the X and Y axis for CCW rosettes (on left strain gage rosette type A, on right strain gage rosette type B).

5.11. Calculating residual stress

When a test is completed, the data can be processed by opening the back-calculation software file EVAL. The general procedure is as follows:

- Start the EVAL program
- Select and open the file to be analyzed, (**Load Data**).
- Select the interpolation setting (**Interpolation setting**)
- Specify the material properties (**Test Setup**)
- Select the processing method for calculating residual stress (**Calculation Setting**).
The following methods are available:
 - Standard ASTM E837-13: uniform stress field
 - Standard ASTM E837-13: non-uniform stress field
 - Standard ASTM E837-08: uniform stress field
 - Integral method
 - Kockelmann method
 - HDM method

The major reference texts for each method available in the software are indicated in the list of references in this manual.

For any additional information about the calculation method and the EVAL, read the **EVAL SOFTWARE – BACK CALCULATION MANUAL**.

5.12. Detaching the system after a hole is completed

If the device is fixed to the surface with adhesive (e.g., HBM X60) it has to be detached by the most appropriate method without risking any harm either to the operator or the system. The device can then be moved to another drilling point.



WARNING:

Eye protection should be worn when removing any adhesive to protect against injury from small particles or chips that could be produced when carrying out this operation. (Eye protection is not supplied with the system)

6. SPARE PARTS

6.1. 1-SINTT

Air turbine for the MTS3000 system. Type: Mach 5.

6.2. 1-SINTCT/1

Inverted cone end mill for the MTS3000 system. Nominal diameter: 1.60 mm. Suggested for:

- Alloys
- Low and medium hardness steels

6.3. 1-SINTCTT/1

Inverted cone end mill for the MTS3000 system with TiAlN coating. Nominal diameter: 1.60 mm. Suggested for:

- Medium and high hardness steels
- Other hard metals (Inconel, Titanium)

6.4. 1-SINTD

Diamond inverted cone drill for the MTS3000 system. Nominal diameter: 1.60 mm. Suggested for:

- Hard surfaces (Hardened materials, Inconel, Titanium, Cr steels)

6.5. 1-SINTC

Spare chuck for 1-SINTT air turbine.

6.6. 1-SINTCTC

Centering drill for the calibration of the optical device of the MTS3000 system.

6.7. 1-SINT-FEET

Strong magnetic feet for residual stress measurement with the MTS3000 system in vertical position.

7. ELECTRONIC DEVICE STATUS

Possible status of the electronic device:

Code	Description
—	Initialization of the controller; displayed whenever the electronic control system is connected to the power supply without being switched on
4	System ready and waiting for switch-on; the electronic control system is powered but not switched on
5	The electronic control system is switched on and the alignment and drilling system stepping motor is ready for operation
C	Home or End limit switches engaged
8	Error. High power amplifier temperature (>85°C)
8 flashing	Warning. High temperature in the power amplifier unit (>75°C).
9	Error. Electronic control system underpowered
9 flashing	Warning. Electronic control system underpowered
A flashing	Warning. Drilling depth exceeds the set depth
E	Shortcircuit in the stepping motor
F	Error in controlling the stepping motor feed angle. The motor cannot perform the instructed movement
F flashing	Warning of a problem in controlling the stepping motor feed angle. The motor cannot perform the instructed movement
H flashing	Warning of a software problem. The program has been interrupted due to an error in running the software
L flashing	Warning. The current position exceeds the set limit

8. SAFETY INFORMATION

8.1. Information on residual risks

There are some residual risks connected with the use of the MTS3000-Restan system.

This risks are connected with the drilling process, particularly:

- Automatic control of the system,
- Chippings projection,
- Acoustic emissions,
- Electrical supply of the motors.

There are some symbols applicated on the system to show the presence of that risks.

<i>AUTOMATIC SYSTEM</i>	<i>CHIPS PROJECTION</i>	<i>ACOUSTIC EMISSION</i>	<i>ELECTROCUTION</i>
			

8.2. Prevention instruction for the user

The following tabel presents the description of each risk and shows the procedures to prevent them.

	DESCRIPTION	AREA OF RISK	DANGEROUS SITUATION	SUGGESTION
	The rotation drill could injure the hands of the user if accidentally started by another user.	Drill area	Positioning of the system, Changing of the cutter	Shout off the electronic device and disconnect the 15 poles connection cables before adangerous situation (see above).
	Chip can be ejected from the drilling area and could be injure the eyes of the user.	Drill area	Positioning of the system. Drilling process.	Use protection goggles during the drilling process
	During the drilling process, the system should emit high frequency noise.	Measurement area.	Drilling process.	Use hearing protection during the drilling process.
	The control motor installed on the system is supplied by the electronic device.	Electronic parts of the system.	Electronic device switched on.	Do not open the electronic devices and the electronic assembled on the mechanical device. Make careful to not damage the 15 poles connection cables.

9. TECHNICAL SUPPORT

If you have any problem with the EVAL software, please contact us:

Support by E-mail:

support@sintechnology.com

Telephone support:

+39 055 8826302 / 8862965

If you need any information about EVAL software, RESTAN - MTS3000 or residual stress measurement by hole drilling please contact us or visit our internet sites:

Info by E-mail:

info@sintechnology.com

Internet sites:

www.sintechnology.com

www.mts3000.com

Please do us a favor:

If you come across an error in RSM software, please let us know.

Thus you will support our efforts toward the continuous development and enhancement of RSM software.

10. REFERENCES

- [1] ASTM E 837-08, "Standard Test Method for Determining Residual Stresses by the Hole-Drilling Strain-Gage Method"
- [2] ASTM E 837-01, "Standard Test Method for Determining Residual Stresses by the Hole-Drilling Strain-Gage Method"
- [3] Schajer, G. S., "Measurement of Non-Uniform Residual Stresses Using the Hole-Drilling Method. Part I - Stress Calculation Procedures", Journal of Engineering Materials and Technology, Vol. no. 110, 1988, pages 338-343
- [4] Schajer, G. S., "Measurement of Non-Uniform Residual Stresses Using the Hole-Drilling Method. Part II - Practical Application of the Integral Method", Journal of Engineering Materials and Technology, Vol. no. 110, 1988, pages 344-349
- [5] Schajer, G. S., "Application of Finite Element Calculations to Residual Stress Measurements", Journal of Engineering Materials and Technology, Vol. no. 103, 1981, pages 157-163
- [6] Schwarz, T., Kockelmann, H., "The hole-drilling method - the best technique for the experimental determination of residual stresses in many fields of application", MTB 29, 1993, Vol. no. 2, pages 33-38
- [7] Flaman, M.T., Herring, J.A., "SEM/ASTM Round Robin Residual Stress Measurement Study - Phase 1", Experimental Techniques, May 1986, pages 23-25
- [8] Flaman, M.T., Herring, J.A., "Comparison of Four Hole-Producing Techniques for the Center-Hole Residual Stress Measurement Method", Experimental Techniques, Vol. 9, No. 8, 1985, pages 30-32
- [9] Schwarz, T., Kockelmann, H., "The hole drilling method – the best technique for the experimental determination of residual stresses in many fields of application", Messtechnische Briefe 29 (1993) No.2, pages 33-38
- [10] Beghini, M., Bertini, L., Rosellini, W., "Genetic algorithms for variable through thickness residual stress evaluation", Proc. 5th European Conference on Residual Stresses, Noordwick (NL) 28-30 September 1999, pages 145-149
- [11] Beghini, M., Bertini, L., "Analytical influence functions for variable residual stress measurement by the hole drilling method", Journal of Strain Analysis, IMechE, Vol. 35 No. 2, 2000, pages 125-135
- [12] Valentini, E., "An automatic system for measuring non-uniform residual stress by the hole drilling method", XIII IMEKO World Congress, Turin, September 1994, pages 1904-1909
- [13] Grant, P.V., Lord, J.D., Whitehead, P.S., "The Measurement of Residual Stresses by the Incremental Hole Drilling Technique", NPL Materials Centre, Measurement Good Practice Guide No.53
- [14] Oettel, R., "Code of Practice No.15 The Determination of Uncertainty in Residual Stress Measurement (using the Hole Drilling Technique)", Issue 1, Sept 2000 EU Project No. SMT4-CT97-2165
- [15] Rendler, N.J., Vigness, I., "Hole-Drilling Strain-Gage Method of Measuring Residual Stresses," Experimental Mechanics, December, 1966, pages 577–586.